



DEVELOPING SMARTER LIFETIME HOMES THAT ENHANCE
WELLBEING FOR ALL GENERATIONS

BY

MISS SUTHIDA KAMOLCHAIWANICH

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE
DESIGN, BUSINESS AND TECHNOLOGY MANAGEMENT
FACULTY OF ARCHITECTURE AND PLANNING
THAMMASAT UNIVERSITY
ACADEMIC YEAR 2019
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THESIS

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ENTITLED

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GENERATIONS

was approved as partial fulfillment of the requirements for
the degree of Master of Science (Design, Business and Technology Management)

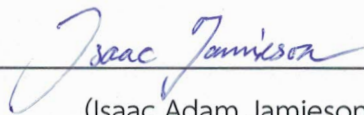
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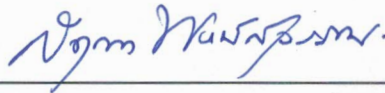
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ABSTRACT

Wellbeing is currently a \$4.5 trillion industry. Though the design of the built environment can affect wellbeing, productivity and health, the building industry and those who supply the technologies and materials used within it have not yet properly tapped into the opportunities they have to create more biologically-friendly smarter-designed environments that can help enhance lifelong wellbeing and performance throughout all stages of life.

This project critically reviews how the design of dwellings and the technologies and materials used within them can impact user satisfaction and wellbeing, and suggests how knowledge of this can aid the creation of smarter design initiatives that aid occupant wellbeing. It also looks at current best practice initiatives with regards to the creation of lifetime homes and use of inclusive design measures. It then suggests how these might be improved still further to increase health, productivity and wellbeing by considering additional factors that scientific research indicates can enhance both short and long-term physical and psychological wellbeing.

This research specifically investigates how to develop smarter lifetime homes that enhance wellbeing for all generations in Thailand through conducting a detailed cross-disciplinary literature review, and through having in-depth interview sessions with design professionals in health and wellbeing and members of the general

public acting as stakeholders. It is suggested that application of the measures proposed within this work will help, amongst other things: aid general happiness and wellbeing; aid the physical and psychological development of children; improve mental functioning and life quality; reduce stress; and help people live healthier lives and remain independent for longer. It is intended that the best practice guidelines that can be generated from this work can be used to help authorities, designers and developers create smarter biologically-friendly lifetime homes as standard. It is also intended that the guidelines and the insights generated from this in-depth examination can be used by those in industry wishing to create more bio-friendly next generation products, and by individuals wishing to enhance the health and wellbeing of both themselves and others to create wellbeing for all.

Keywords: Biologically-friendly, Inclusive, Smarter Lifetime Homes, Health, Wellbeing

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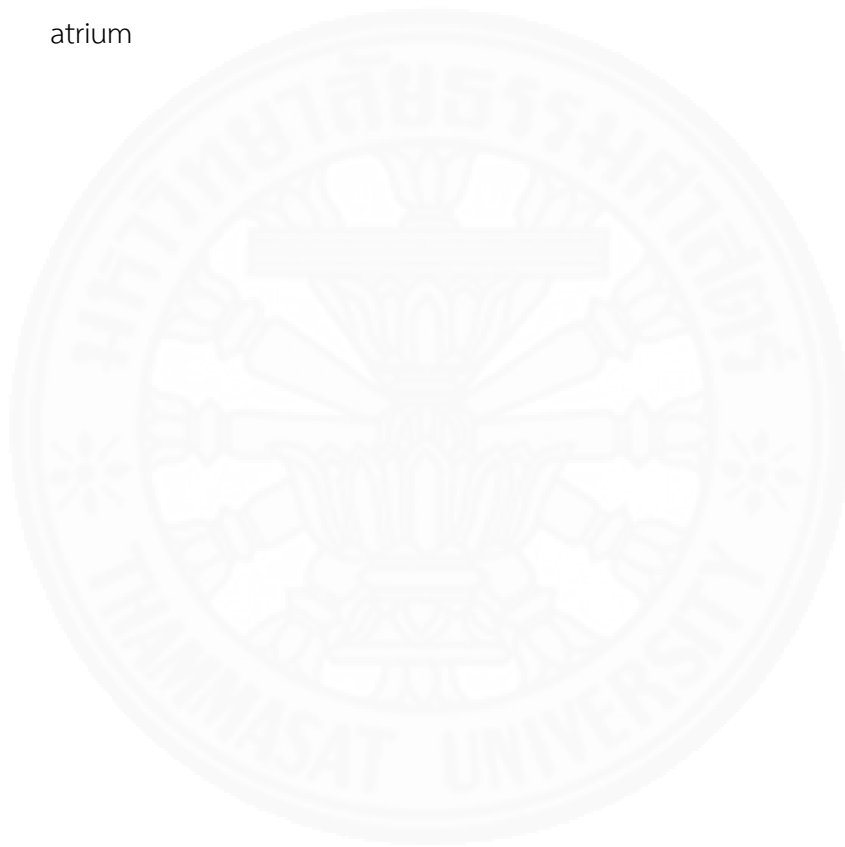
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CHAPTER 1

INTRODUCTION

1.1 Research Background

Wellbeing is currently a \$4.5 trillion industry (Global Wellness Summit (2019), 2020 Global Wellness Summit). Though the design of the built environment can affect wellbeing, productivity and health, the building industry, and those who supply the technologies and materials used within it, have not yet properly tapped into the opportunities they have to create more biologically-friendly smarter-designed environments that can help enhance lifelong wellbeing and performance throughout all stages of life.

Currently, the wellness real estate business is a new industry that gives importance to the health of people. It is intended to meet the conceptual framework of design, building and housing development to respond to the health challenges of today and in the future. It is in its infancy as an industry. It is a development, and expansion of, the old concept of designing better quality residences. Both green building designs and the appropriate integration of the right kinds of innovations can be used as new indicators to capture the Return on Wellness (ROW) (Global Wellness Institute, 2018). It is still in the process of discovering its true identity and learning what it is really capable of doing to create better health and quality of life for all.

The designs of most housing focus primarily on young physically able individuals, rather than individuals at all stages of their life journey, and are not designed to cope with many potential disabilities, injuries or infirmities. The Lifetime Homes approach helps address this issue, but still does not fully address the impact that design can have on physical and psychological wellbeing.

1.2 Research Questions

1) How can we develop smarter lifetime homes that enhance wellbeing for all generations?

2) How does the design of dwellings, and the technologies and materials used within them, impact user satisfaction and wellbeing, and how can it help enhance lifelong wellbeing all stages of life?



Figure 1.1 Bosco Verticale building designed by Stefano Boeri Architetti (2019)

1.3 Research Aims

The main aim of this thesis is to critically review and assess the current situation with regards to the design and refurbishment of domestic properties within Thailand and suggest how ‘smarter lifetime homes’ that enhance wellbeing for all generations could be cost-effectively created as the new norm.

In order to achieve this objective, the following specific tasks were undertaken:

1) Critical review of current building guidelines, standard designs and design details used in conventional new-build Thai housing, and current best practice standards as related to Lifetime Homes and Inclusive Design.

2) A detailed review was also undertaken of cutting-edge scientific research to assess factors that can be taken into consideration to help create more biologically-friendly dwellings that increase both short and long-term wellbeing for all.

3) Where possible, mention has been made of the possible cost-benefits that could arise from adopting proactive measures to create more biologically-friendly lifetime homes.

4) An initial blueprint set of best practice guidelines was then created for assessment by design professionals and select members of the general public. After the feedback received, a finalised blueprint for best practice guidelines was then proposed.

1.4 Research Objectives

1) To review how the design of dwellings, and the technologies and materials used within them, impact user satisfaction and wellbeing.

Understanding about the problems of current designs of dwelling, categorising problems before set factors/ indicators.

2) To look at current best practice initiatives with regards to the creation of lifetime homes, and inclusive design measures.

Study current best practice as related to wellbeing to determine additional factors that may improve such initiatives still further.

3) To consider additional design factors that scientific research indicates may enhance both short and long-term physical and psychological wellbeing.

Set key indicators to study the impact to wellbeing of all generations at all stages of life. Determine the variables that are the most important factors as related to improving wellbeing.

1.5 Scope of Research

In this research study about how the design of dwellings impact users, a critical review is undertaken of how standard dwelling design can be improved to enhance wellbeing at all stages of life. It is proposed that the findings made could be adopted throughout the whole building industry to help improve the biological friendliness of the built environment and also help improve the quality of all people's lives at all stages of their life journey.

1.5.1 Location Scope

In this present study, the investigation of how the designs of dwelling can be improved to improve occupant wellbeing is being assessed in the context of Thailand real estate development and refurbishment of existing properties in the Bangkok Metropolitan Area.

1.5.2 Theories Scope

1) Design standards and best practice guidelines for housing

- (1) Universal design standard in housing
- (2) Lifetime Homes standard
- (3) Older people housing design theories
- (4) How the design of the environments, and the specification of materials and products, used within individuals' home properties can impact the health, wellbeing and productivity of occupants.

2) Study of user viewpoints at different periods in life.

The viewpoints of different end-users can provide important insights into design needs at different stages in life's journey:

- Single person
- Couple without children
- Couple with child/children
- Single parent with child/children
- Older couple

The smarter design of buildings can take into account and plan for residents' changing needs and factor in how wellbeing can be improved for each of them.

1.5.3 Select a Group of Key Informants

Select a group of design professionals with expertise in health and wellbeing building design from the Research Innovation Sustainability Center (RISC) and from the Faculty of Architecture and Planning Thammasat University. Undertake in-depth interviews with those professionals and also selected members of the public (single person; couple without children; couple with child/children; single parent with child/children; and older couple) as representative of buyers on the housing market and integrate their feedback and comments with findings made from the critical literature review to create an initial draft blueprint of best practice guidelines on "Developing Smarter Lifetime Homes That Enhance Wellbeing For All Generations". This will then be refined as a final draft blueprint for best practice guidelines on this topic.

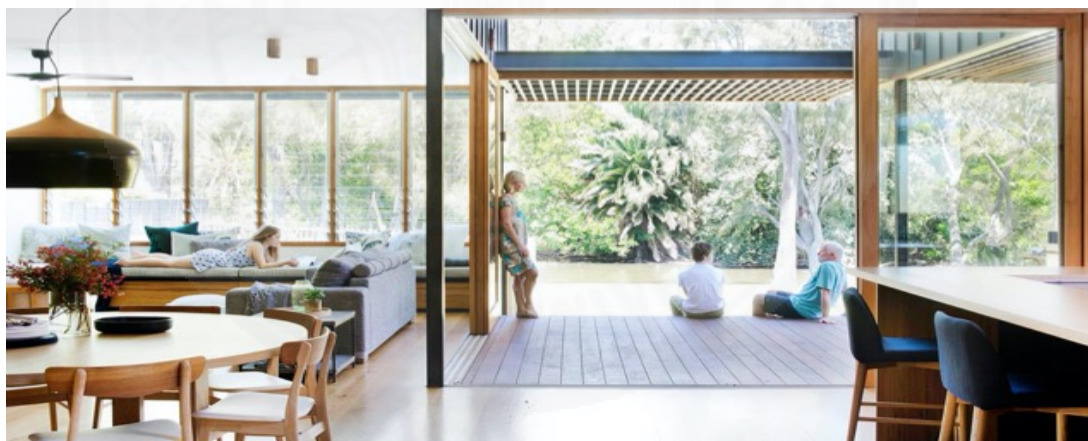


Figure 1.2 The Aulds' forever home, A sustainable house designed for modern family life

Source: homestolove, (2018)

1.5.4 Data Collection and Analysis

Data collection and analysis period from 1 January - 30 April 2020

1.6 Research Hypothesis

It is possible to develop smarter lifetime homes that are intentionally designed to enhance wellbeing for all generations through bringing together the findings of medical research and research from related industries to create more biologically-friendly homes that better enhance both short and long-term user wellbeing.

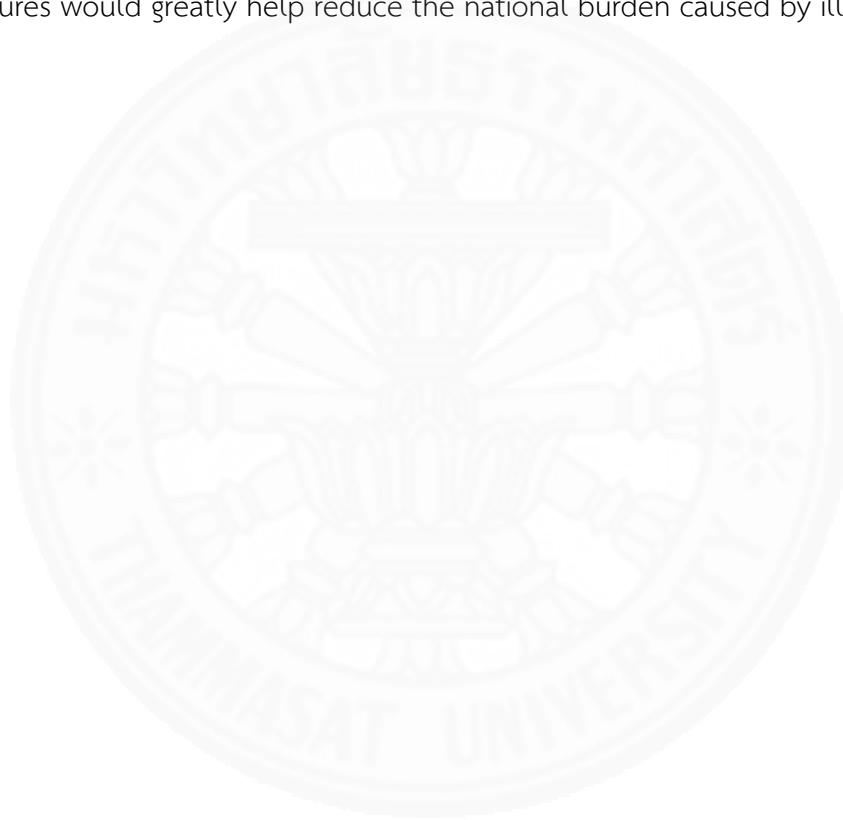
1.7 Conceptual Framework

It is possible to develop smarter lifetime homes that are intentionally designed to enhance wellbeing for all generations through bringing together the findings of medical research and research from related industries to create more biologically-friendly homes that better enhance both short and long-term user wellbeing.

1.8 Expected Outcomes

This research will find ways to increase the quality of life for people of all ages through enhancing the design of dwellings to improve both long and short-term wellbeing. It is proposed that application of the measures that are proposed within this work will help, amongst other things: aid general happiness and wellbeing; aid the physical and psychological development of children; help individuals have better mental functioning and higher life quality; reduce the effects of stress; and help people live healthier lives and remain independent for longer.

It is intended that the best practice guidelines that can be generated from this research can be used to help authorities, designers and developers create smarter biologically-friendly lifetime homes as standard. It is also intended that these guidelines and the insights generated from this work can be used by those in industry wishing to create more bio-friendly next generation products, and by individuals wishing to enhance the health and wellbeing of both themselves and their loved ones to create wellbeing for all. It is proposed that the widespread adoption of such measures would greatly help reduce the national burden caused by ill health.



CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

At present, Thailand has a population of around 69.7 million people. The population of Thailand continues to grow, though this rate of growth is predicted to keep shrinking, with a slight decline in numbers being foreseen by 2030 when a population size of around 69 million is predicted. It is then expected by 2050 to shrink further down to 65 million, and by 2099 to be reduced even further to 46.3 million. (World Population Review, 2019) (Figure 2.1)

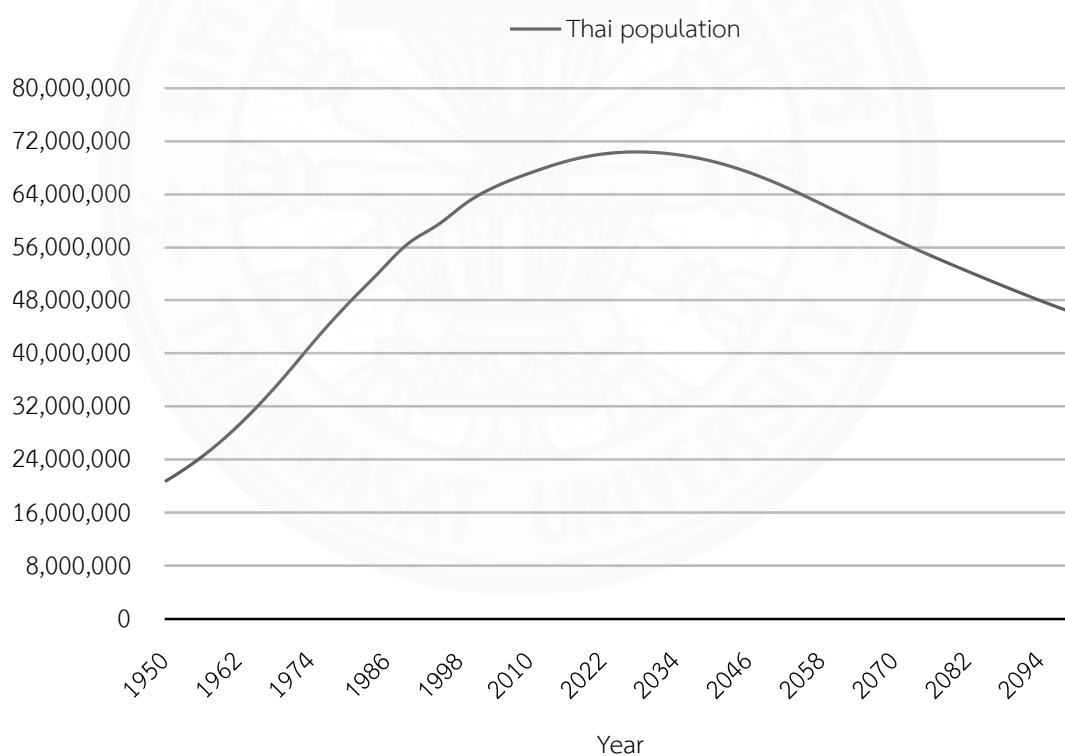


Figure 2.1 Past and predicted population growth for Thailand

Source: World Population Review (2019)

The reductions in birth rates within Thailand are below the levels required for replacement, and along with the trend of increased longevity have caused a big change in the age structure of the population (Figure 2.2).

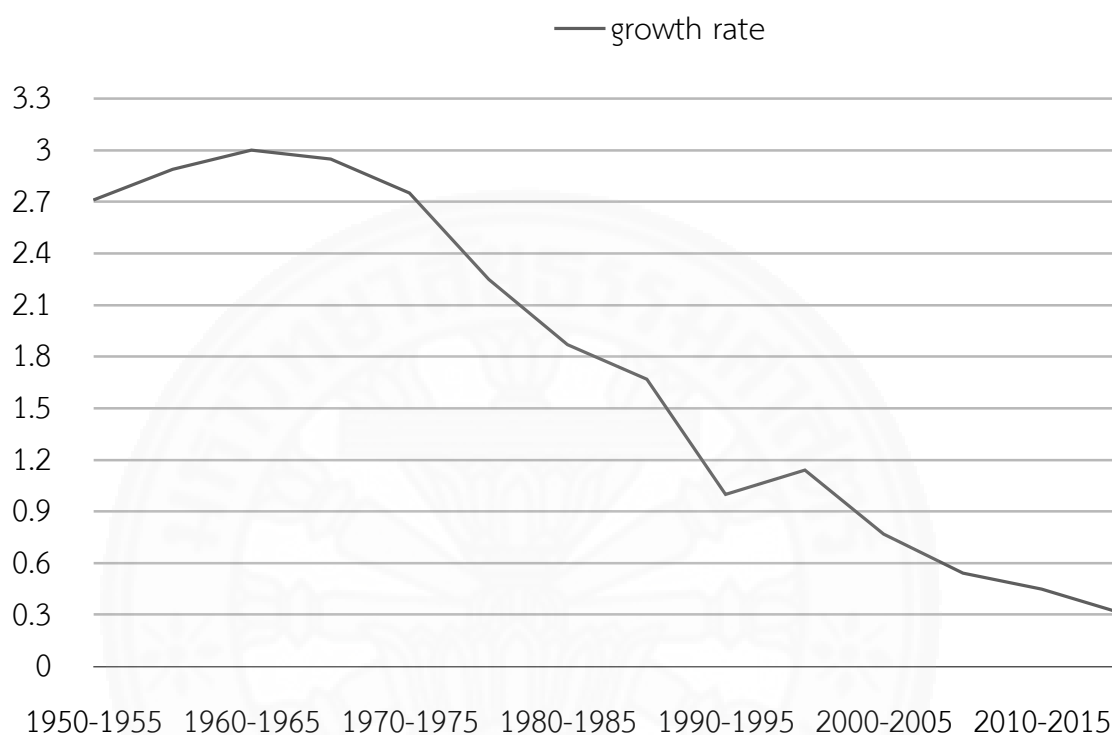


Figure 2.2 The growth rate of Thai population

Source: World Population Review, (2019)

Over the past several decades, the birth rate of Thailand has dropped dramatically from 3 percent in the 1970s to less than 1 percent at the present time. In the future, this figure is expected to decline further, while the proportion of the older population is increasing rapidly, resulting in changes in the age structure of the population in Thailand. This means that Thailand is facing problems related to social security and the healthcare expenses of people in the nation. Therefore, Thailand needs to have national policies and programs that prepare the older people for long-term care (Trend, 1999). It also places greater emphasis on the need to ensure that affective design measures are taken to help them, and other members of the

population, to remain healthier longer. Furthermore, there is also need to ensure that the environments we live in, and the technologies we use, do not compromise fertility.

Table 2.1 Population aged 60 and older according to United Nations projections, 2015-2050

	2015	2020	2025	2030	2035	2040	2045	2050
Number in 1000s (medium fertility variant projection)	11,690	13,270	15,988	18,687	20,913	22,403	22,970	22,953
Ratio to 2015	1.00	1.14	1.37	1.60	1.79	1.92	1.96	1.96

Adapted from: United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision.

From the table above showing the results of the UN forecast that the number of older people will continue to increase for the foreseeable future (Table 2.2). Thailand is experiencing a rapid rise in the number of older people and is predicted to rise from the 10th place in Asia in 2015 to the 6th in 2035 (Table 2.2). A very rapid change in just 20 years.

Table 2.2 The proportion of populations aged above 60 years in Asia

	2015	%	2035	%
1	Japan	32.8	Japan	39.9
2	Hongkong, China	21.8	Korea	35.5
3	Georgia	20.3	Hongkong, China	35.3
4	Chinese Taipei	18.6	Singapore	34.1
5	Korea	18.4	Chinese Taipei	33.1
6	Singapore	17.9	Thailand	30.2
7	Cyprus	17.7	Macao	28.8
8	Israel	15.8	China	28.5

Table 2.2 The proportion of populations aged above 60 years in Asia (continue)

9	Armenia	16.8	Cyprus	26
10	Thailand	15.6	Georgia	25.9

“Thailand is predicted to become an ‘aged’ society in 2031 and a ‘super-aged’ society in 2050, with 20 and 30 percent of the total population being aged citizens, respectively. This means that out of every three Thais, one will be a senior citizen.” (Sing, 2019)

This rapid change in demographics has been observed in several countries around the world, but *“Thailand will be the first middle income, developing country enter an aged society”* (Sing, 2019). That presents a big problem to the healthcare system in terms of the increased potential burdens it may have to deal with, and also with regards to future workforce numbers due to lower fertility which is predicted to result in reduced economic growth. *“Data published last month by the United Nations show births in Thailand have dropped to a level on par with Switzerland and Finland, two ultra-wealthy countries with which it has almost nothing else in common.”* (Towie et al., 2019)

According to the predictions, the size of the older population is increasing whilst birth rate is decreasing. The reduced number of individuals within the working-age population means the labour force is shrinking, resulting in insufficient numbers of workers and reduced economic growth. Among the consequences following from this is the fact that the government can no longer drive the economy to bring sufficient tax money to support the older population anymore. At present, Thailand is entering an aging society. This is causing the government to have serious concerns about the wellbeing of the older population. In the past, measures undertaken in Thailand often did not take into account a number of the matters related to society and the health of the older people that may affect the well-being and sustainable development of the country.

As the general age of the population increases, so does the healthcare challenges that the nation faces. Creating healthier living environments, that are also

better designed environments to allow greater inclusivity, societal cohesion, and encourage greater fertility, can create significant long-term benefits for all, increase wellbeing, help drive innovation and enhance the nation's Gross Domestic Product (GDP).

Environmental design covers both the materials used and technologies used and how they are used. Scientific evidence shows that: "*The built environment has direct and indirect effects on mental health.*" (Evans, 2003) but typical building standards for general buildings are not aware of the degree to which building design can impact health and the benefits that good building design can have to the general economy. Moreover, the use of various materials and products within the environment may have adverse effects on health. Therefore, bio-friendly environmental design should be able to protect occupants from elements that can be harmful to health. Healthy design covers real estate that can increase efficiency and improve quality of life. In terms of emotions, mental health, sleep well. Which those designs should consider natural light or use nature as an intermediary combined with the use of technology to improve building quality itself. In addition, good environmental design should promote holistic health behavior, such as designing an environment that is conducive to exercise or the design of an environment that can be used anywhere for activities with others to promote and develop community networks which has a positive impact on quality of life and aspects of wellness, such as the environmental, social, and economic dimensions of wellness (Global Wellness Institute, 2018).

"What Is Unwell in the Places We Call Home?" "The way our homes and communities have been planned, designed, and built in the last century is reinforcing lifestyles that make us sick, stressed, alienated, and unhappy" (Global Wellness Institute, 2018). This demonstrates how over the past 100 years, planning and designing of architectural environments, including city planning, have often affected life in terms of health and emotions. Technology too has advanced tremendously, but can cause enormous negative impacts when not developed or used appropriately. It causes inequality, people cannot access a good environment. It can even effect fertility.

The environment is the main cause of health problems and deaths. *“Research has shown that the determinants of chronic disease are less than 15% genetic and more than 85% environmental and behavioral factors. Our health outcomes are intimately tied to where we live and how we live. Yet, when we look around, we must ask: How can we stay healthy when our built environment is working against us?”* (Global Wellness Institute, 2018). Living in a bad environment can affect long-term health. Asthma and lung cancers are all caused by inhalation of pollution. In addition to being a contributing factor to various diseases, poor environmental quality also affects sleep and other aspects of general wellbeing.

As mentioned earlier, the Global Wellness Economy is presently worth \$4.5 trillion (Global Wellness Summit, 2019), and the Global Wellness industry is now one of the largest and the fastest growing industries in the world, having exhibited 17.8% growth since 2015. Having, obtaining and retaining good health are things that many people now realise are important. More members of the general public are starting to realise how the environments they live in can affect their health for good or bad. Therefore, modern homes may not just be considered on first appearances, but as environments that can impact our wellbeing as a result of their design, layout and the actual specifications and usage of the materials and technologies within them. In addition to helping meet the increased health and wellbeing needs of users, the arrival of the aging society is another factor that has driven the Wellness Lifestyle Real Estate trend to a great extent. In 2006, there were around 11% of the world’s population aged 60 and over. A figure that is expected to increase to 22% by 2050. (WHO, 2007). In Thailand, figures are expected to increase to 35.7% by 2050 (Figure 2.3). (United Nations, Department of Economic and Social Affairs, 2017).

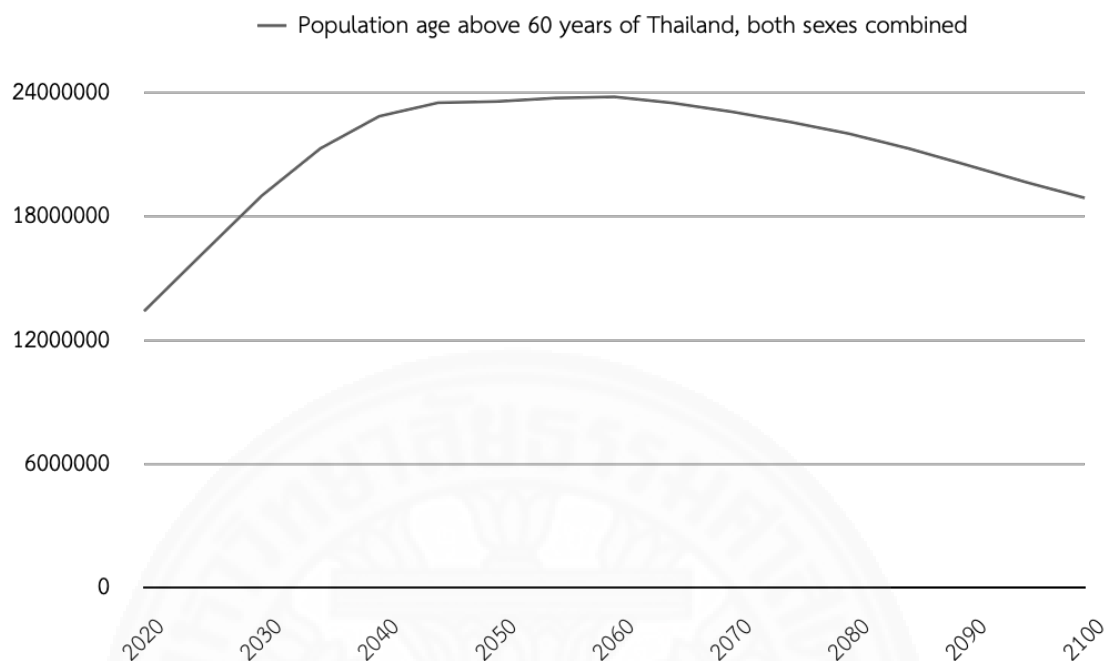


Figure 2.3 Predicted population age above 60 years in Thailand 2020-2100

Adapted from: United Nations, Department of Economic and Social Affairs, Population Division (2017). World Population Prospects: The 2017 Revision.

As environmental conditions can strongly affect health and quality of life, the design of the built environment we live in is an important factor that can greatly affect us all. At present, this fact has been little considered by the building industry in Thailand, or in many other countries elsewhere in the world! This situation exists, despite there are being numerous scientific studies showing areas that should be taken into consideration in the design of both new builds and refurbishments when wishing to reduce risk, increase wellbeing and lower healthcare costs. Thailand should see addressing this shortfall as an opportunity to improve the general health, wellbeing and productivity of its citizens and should set a standard of housing design and best practice initiatives that seriously take into consideration how to enhance the health and wellness of dwelling residents.

Wellness Real Estate incorporates intentional wellness elements into its design, materials and building: *“Wellness lifestyle real estate is defined as homes*

that are proactively designed and built to support the holistic health of their residents” (Global Wellness Institute, 2018). The Wellness Real Estate industry has begun to realise that the creation and maintenance of good health starts where people spend most of their lives. The Wellness Real Estate industry is therefore rapidly growing within the real estate sector. For comparison: “the \$134 billion wellness real estate market is now about 1.5% of the total annual global construction market and about half the size of the global green building industry. There are now more than 740 wellness real estate and community developments built or in development across 34 countries – a number that grows weekly” (Global Wellness Institute, 2018).

The design of residential buildings is an important issue. At present, the designs of most housing focus primarily on young physically able individuals, rather than individuals at all stages of their life journey. They are not designed to cope with many potential disabilities and injuries, or help reduce the likelihood of illness and ill health. Also, they are not generally designed for use by people of all ages, or with the principles of universal design in mind (Table 2.3). This shortfall may have serious long-term consequences for buyers as they themselves age, or if they suffer from accidents or ill-health.

Table 2.3 This house is one of the residential projects in Thailand


Picture	Information
	<p>Entrance level / Doorway</p> <p>The entrance to this house has a front porch which is laid with ceramic tiles. This area is approximately 4 × 1 meters. It has a fixed glass door with dark gray UPVC frame. The door frame also has an upstand. It would be difficult for people in wheelchairs to get in and out of this home.</p> <p>Ideally the doorway should be wide enough to easily allow wheelchair entry. Additionally, the design should incorporate a ramp or other means to enable easy access by wheelchair. (Palmer, J. (2013)</p> <p>Ideally, low iron glass, or neutral-tinted glass, should be specified instead of standard tinted glass for health reasons (Jamieson, I.A. (2020), personal discussion with author; Ott, 1973).</p>

Table 2.3 This house is one of the residential projects in Thailand (continue)


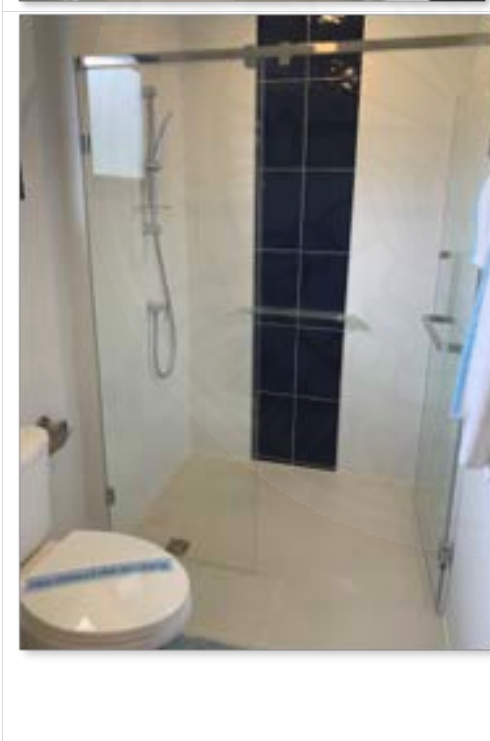
	<p>Hallway / Kitchen</p> <p>The kitchen is approximately 2.4 × 3 meters in size. In many modern Thai designs the kitchen floor level is about 8-10 centimeters lower than the floor level in the hallway. This change in level makes it difficult for disabled people to get in and out of the kitchen. Additionally, the change in floor level presents a trip hazard.</p> <p>Ideally, the kitchen floor would be at the same level as the hallway. Having them both on the same level would also simplify construction techniques and help save costs.</p>
	<p>Bathroom layout</p> <p>The shower area is 1.35 × 0.90 meters. There is a step down from the main bathroom area into the shower area. This presents a trip risk and makes it difficult for disabled people to use.</p> <p>Ideally, a wet room design would be chosen instead where all of the flooring is at the same basic level with a slight fall towards the drain.</p>

Table 2.3 This house is one of the residential projects in Thailand (continue)


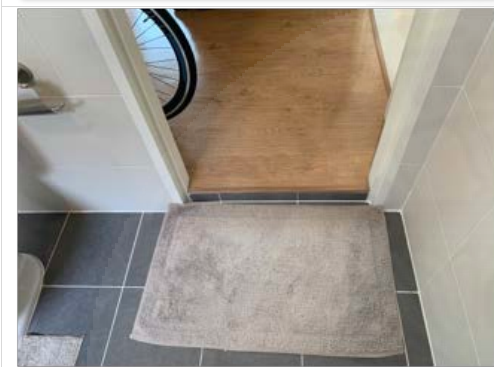


	<p>Bathroom floor level</p> <p>The floor in the illustration shown is about 5 centimeters lower than the floor level in the adjacent hall. The change in level makes it difficult for disabled people to get in and out of the bathroom and also makes it difficult for them to use the shower. Additionally, the change in floor level presents a trip risk. It also makes construction more complicated and increases costs.</p>
	<p>Bathroom floor level</p> <p>The floor is slightly lowered. Ceramic tiles are used as the floor and wall materials of the bathroom area.</p> <p>Ideally, it should not have a change in level between area as this causes inconvenience to people who use wheelchairs or have difficulty in walking. Should make the floor at the same level.</p>
	<p>Bedroom This room is approximately 3 × 3.55 meters in size.</p> <p>Ideally, its glazing should help block infrared wavelengths to reduce heat build-up. Also, the curtain should contain a blackout layer to protect occupants from outdoor light pollution at night. The plug height does not conform with the Lifetime Homes standard (which stipulates heights between 45 - 120 cm above floor level).</p>
	<p>Doorways/ Hallways</p> <p>Ideally, the hallway should be at the same level as the rest of the rooms on that floor to help prevent the likelihood of accidents. This would enable people of all ages, and physical abilities, such as wheelchair users, walking stick users and young children to use it without restriction.</p>

Table 2.3 This house is one of the residential projects in Thailand (Continue)

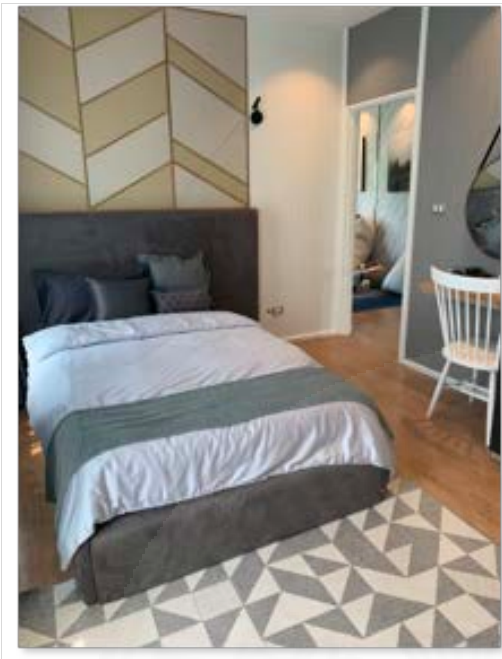
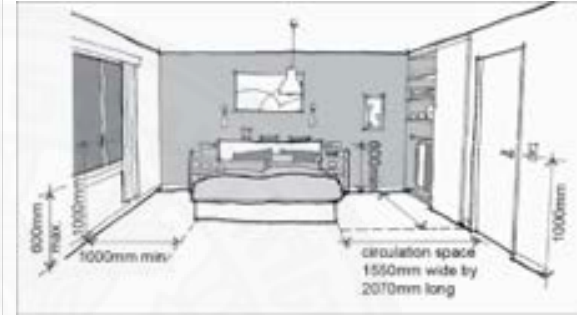
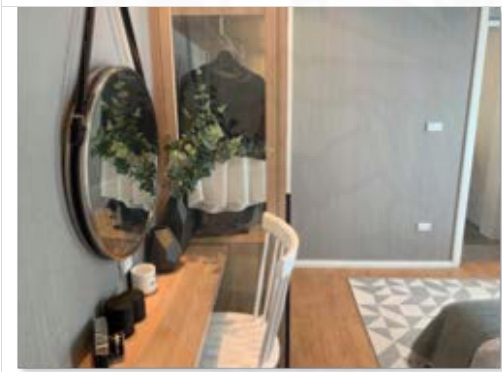

	<p>Bedroom</p> <p>The space beside the bed is not enough for everyone. (People who use a wheelchair or walking sticks or frames cannot easily get in and out of this room).</p> <p>Refer to: The livable and adaptable house from yourhome.gov.au</p> 
	<p>Bedroom</p> <p>The space beside the bed isn't wide enough for everyone. (People who use a wheelchair or walking stick can't easily get in and out of this room).</p>
	<p>Bedroom (2) This room is approximately 3 x 3.4 meters in size.</p> <p>The plug height does not comply with that required in the Lifetime Homes standard (which stipulates that they should be located at heights of between 45 cm and 120 cm above floor level).</p>

Table 2.3 This house is one of the residential projects in Thailand (Continue)


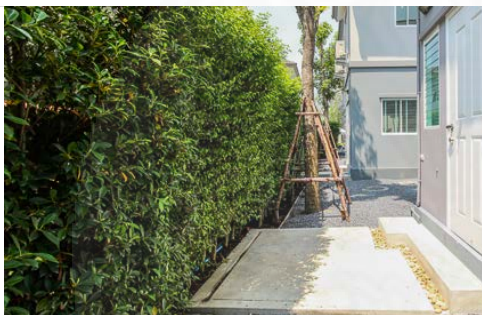

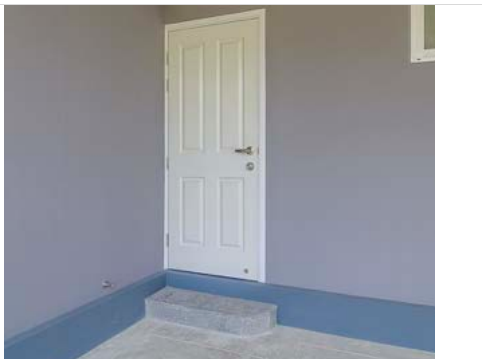

	<p>Entrance level</p> <p>Ideally, Entrance level shouldn't have a step or if necessary to have step, it should have slope way for wheelchair users. Exterior sliding doors may be difficult to use due to the width and weight of each door. In addition, the accumulation of dirt in the door rails can cause the door to not work. Hanging top sliding door may be easier to move than a sliding door on the bottom rail. Choose nylon wheels or roller bearings with self-lubricating metal. Recommended clear opening 90 cm (a minimum clear opening of 840 cm is only acceptable if unavoidable).</p>
	<p>Entrance level</p> <p>Ideally, the entrance level should not be stepped, and should have a ramp if a chance in level is necessary. If a step is required, it should have provision for a slope way for wheelchair users too.</p>
	<p>Entrance level/ Doorways</p> <p>Exterior sliding doors may be difficult to use due to the width and weight of each door. In addition, the accumulation of dirt in the door rails can cause the door to not work. Hanging top sliding door may be easier to move than a sliding door on the bottom rail. Choose nylon wheels or roller bearings with self-lubricating metal. Recommended clear opening 90 cm (a minimum clear opening of 840 cm is only acceptable if unavoidable).</p>
	<p>Entrance level</p> <p>Ideally, Entrance level shouldn't have step or if necessary to have step, it should have slope way for wheelchair users. And refer to Lifetime Home Standard. (Lifetime Homes standard (2012). All entrances should be illuminated.</p>

Table 2.3 This house is one of the residential projects in Thailand (Continue)

	<p>Bathroom layout</p> <p>Ideally, the bathroom should have more space to be able to separate the wet and dry parts. And have adequate space for wheelchair users to enter and exit comfortably. There should be handrails for people of all ages, or structural provisions made for these to be easily installed, and lower basins for wheelchairs and children to easily access and use.</p>
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Over the past year, the attitude to Wellness Real Estate in Thailand has changed and more developers are becoming prepared to deal with the aging society of Thailand. Property developers are collaborating with hospital operators in creating real estate projects for health by focusing on older people for which the project will mainly provide care and services for those people (CBRE, 2018).

Sansiri Company announced a joint venture with Tokyu and Samitivej Hospital to jointly develop healthy real estate projects. By planning about a growing health trend in Thailand. There are also other companies that are starting to look for opportunities to develop healthy real estate projects. Most developers are still in the trial phase in their investigative journey because there is not a single solution that will meet all the needs as people's needs change all the time. Which the real estate development company jointly developed the project with the hospital is a plan of care and service for the older people (CBRE, 2018). Which can explain that these companies focus on the older people. But such schemes are not really inclusive with regards to meeting the needs of people at all stages of their life journey. Also, unless they are properly planned, they may create boundaries of separation instead of embracing the full circle of life that can take place within families and communities.

It is proposed that biologically-friendly universal design standards should be created and used, ideally as standard, when designing all dwellings in future. The existing universal design standard is intended to cover everyone's use including those with mobility limitations (Van Roosmalen et al., 2006). By upgrading these still further

to enhance the health and wellbeing of occupants at all stages in their life journeys even greater benefits can be achieved.

2.2 Concepts and Theories About Universal Design Features in Housing

The universal design in the housing is a design that can be used to cover and useful for everyone. It is proposed that the adoption of the concepts of universal design and deliberately enhancing wellbeing through the biologically enhanced design of environments will be especially important for Thailand and other countries heading towards entering the aging society. The universal design is a product design that does not have limitations to the age range and usability. It also can be used independently for the older people and all ages (Demirbilek, 2015). It has been proposed by Jamieson (Jamieson, 2020), personal discussion with author) that the same holds true for biologically enhanced design.

As the population gets older, universal design is becoming a more popular concept to adopt that will enable the building homes for longevity and/or disability. Universal design concepts and strategies that are properly considered at the initial stage of design concepts can be achieved without significant cost increases in the overall construction budget. For example, installation of textured non-slip flooring helps prevent slip and fall risks. Concepts such as wider corridors and passages represent increased circulation/ flexibility, and later, when needed, also increase mobility and barrier-free access that help seniors stay in their homes longer (Lanteigne, 2017). Additionally, when such extra width is not required for circulation purposes, it can also be used for circulation, helping to meet one of the needs of many buyers identified in the work of Finlay et al. (2012).

The definition of Universal Design refers to the Centre for Universal Design's 1997 definition: "*Universal design is design that's usable by all people, to the greatest extent possible, without the need for adaptation or specialized design*" (Mace, 1985). It has the following accompanying principles and guidelines: equitable use; flexibility in use; simple and intuitive in use; perceptible information; tolerance for error; requires

low physical effort; and size and space appropriate for approach and use (Calkins, Sanford, & Proffitt, 2001).

Universal design is an important concept that is designed for the convenient, safe, and equal use of areas by individuals of all ages and every physical condition. It is the construction of places and facilities for people of all genders, all ages, whether they be normal physically able people, older people, the disabled, rehabilitation patients, pregnant women, or children. It is a design concept that seeks to provide benefits for everyone.

The universal design concept was first created in the United States as the result of there being an increasing number of people with disabilities and that existing items were an obstacle for them. In 1990, the American National Standards Association enacted the American Disabilities Act to eliminate barriers to persons with disabilities by guaranteeing equal rights for people with disabilities, but this law does not apply for all products or services. The inventor of this design concept is Ronald L. Mace, who is disabled himself. He initially started experimenting and designing personal items for individuals with disabilities. After that, this principle was used for the development of product design for people with disabilities and further developed into a product design for all people, with an equal emphasis on enabling all people to use the same design product or service. This approach helps reduce the alienation/ differences between people in the society (Jarurvedyasom, 2018).

The United Nations is trying to spread and promote the concept of civilization so that people with disabilities get the amenities of living in the building and the environment under the promotion of Non-Handicapping Physical Environment for Disabled persons has published and promoted by December 1995. The Principles of Universal Design Version 1.1 and developed to version 2.0, released in April 1997 is an environmental design, creating a place and things so that everyone in the society can use the full and equal benefits without any special or specific modifications to any group of people (Jarurvedyasom, 2018).

The "Principles of Universal Design" were developed by a team of U.S. experts organized by the Center on Universal Design at NC State University in the

1990's. Accompanied by a set of guidelines for each Principle, they were a valuable tool for clarifying universal design for early adopters, and are still widely used today (WBDG Accessible Committee, 2017).

The Seven Principles of Universal Design:

- Equitable Use
- Flexibility in Use
- Simple and Intuitive
- Perceptible Information
- Tolerance for Error
- Low Physical Effort
- Size and Space for Approach and Use

At present there are the eight goals of universal design were recently developed in an effort to improve principles, clarifying the concepts of universal design, combining human performance, health and wellness, and social participation as a result and resolving context and culture. The universal design must deal with inequality in order to overcome the perceptions that arise in achieving other important design goals (Steinfeld and Maisel, 2012).

“One obstacle to the acceptance of universal design in middle and low-income countries is the perception that it is often seen as an expensive ideal or Western value. It is true and appropriate to acknowledge that design strategies can be different or adapted to different locations and by different cultures. In some places, achieving a level of accessibility similar to Western norms may be needed. Therefore, it is important that the universal design strategy also emphasises the cultural values relevant to the social, economic and physical contexts. In addition to addressing these concerns, the eight goals of universal design connect the international design with knowledge and identify measurable outcomes: (Steinfeld and Maisel, 2012)

- Body fit: Supports a variety of body sizes and abilities.
- Comfort: Keeping demands within desirable limits of body function.

- Awareness: Ensures that important information for use is easily recognized.
- Understanding: Creates a method of operation and is easy to use, clear and unambiguous.
- Wellness: Support to health promotion, avoidance of disease, and prevention of injury.
- Social integration: Treating all groups with dignity and respect.
- Personalization: Combines opportunities for selection and expression of personal preferences.
- Cultural appropriateness: Respecting and reinforcing cultural values and the social, economic and environmental context of any design project.”

2.3 Concepts and Theories About the Lifetime Homes Standard

The initiative for the Lifetime Homes standard came from discussions in the late 1980s between the Helen Hamlyn Foundation and the Habitat House Association. The 'Lifetime Homes' concept was first adopted in connection with a project launched by the Helen Hamlyn Foundation in 1989 and applied at that time to help meet the needs of older people. The Habinteg Housing Association still had concerns at that point with regards to design related inaccessibility and inconvenience in architectural schemes. And Habinteg Housing Association are recognized as initiatives by the Helen Hamlyn Foundation may have wider applications which will fit in with the purpose of creating an integrated and inclusive housing for a broad group of people with different needs. After that, they formed a group with the Joseph Rowntree Foundation. The JRF has gathered many housing experts consisting of architects, developers, consultants, industry experts in early 1990s. They have collaborated to develop a set of design standards with improvements to meet the needs. Which has determined the criteria for life time homes standard design into 16 criteria (Goodman,

2011).

In 2008, JRF transferred leadership role in promoting the guidance and standard management to Habinteg Housing Association. In the following year, Habinteg Housing Association convened a new technical advisory group consisting of a range of practitioners and planners involved in housing design, development, consultation, access and modification. This group is considered the 16 design criteria in excellent detail with the aim of making it more possible for volume developers to use as standards across all ranges of modern home types and in both high and low density developments (Goodman, 2011).

The results of the research, although not published by the UK government, were entered into a discussion of a technical advisory group which then proposed a number of amendments to 16 design criteria. The proposed amendment was released for public consultation and the amendment to the original residence for life. The standard was published in 2010. The technical recommendations in this manual are related to this 2010 standard (Goodman, 2011).

The Lifetime Homes standard was originally founded in 1990 to incorporate a set of the principles of good co-housing design. The modern design of a good residence in this context is thoughtful design that increases utility, independence and quality of life while not compromising other design issues such as aesthetics. It can also, if correctly undertaken help reduce costs. Standardisation is an expression of 'inclusive design'. It seeks to provide design solutions in house with general needs that can meet the changing needs of the widest range of operators. This gives many families have more choices when deciding on their type of property where they want to live (Goodman, 2011).

The Lifetime Homes property is more convenient for residents. This includes people who are not very active may override the need for significant changes in order to make homes suitable for the specific needs of occupants. Added to the convenience provided by the standard is useful to everyone in ordinary everyday life. This standard is based on the five principles inform these reasons for the design for a lifelong living needs (Goodman, 2011).

1. Principle 1: Inclusiveness

An inclusive environment is intended to assist in use by everyone regardless of age, gender, or disability. It is not trying to meet everyone need, but with consideration to the different needs of individuals and households whose purpose is to break unnecessary barriers. Lifetime Home designs are flexibility and adaptability within design and structure allow Lifetime Home to meet a wide range of needs over times (Goodman, 2011).

2. Principle 2: Accessibility

To integrated design aims at the widest range of people, including people with physical and/ or sensory impairments, the older people and children, convenient and independent access within the environment (External and internal) and the accessing to the service with equality.

The lifetime home is designed with special attention to:

- 1) The ease of approaching the home
- 2) Circulation within home
- 3) The approach to key facilities.

Hallways, doorways, stairs way, access to the upper floors and spaces to approach and access necessary facilities and controls in the home are all carefully considered (Goodman, 2011).

3. Principle 3: Adaptability

Adaptability means a building or product that can be adapted to a person's changing needs at a particular time or to suit the needs of different users. A lot of adjustments within the lifetime home should be more cost-effective because the designs support their future, provisions from the outset (Goodman, 2011).

4. Principle 4: Sustainability

Sustainability in this context refers to a strong and stable community driven by essential accessible, components aimed at meeting current and future needs, including homes, facilities, products, and service. The accessible, flexibility and adaptability of a lifetime home ensures the term needs and desires of the dwelling. It tends to remain popular over time for both existing and new households and able to

participate in the creation of thriving and popular neighborhoods and communities (Goodman, 2011).

5. Principle 5: Good Value

The design criteria have been carefully considered so that they can be included in the design of housing and construction at the stage of the building only has an impact on the additional cost. The lifetime homes are combining design and ease of use. Adjustment from the outset that has the potential for significant savings in the future and worth in the long-term (Goodman, 2011).

For the 16 criteria of design features that create a flexible, accessible, adaptable housing. The figure below (Table 2.4) is an analysis of requirements and the applicability (BCIS, 2012).

Table 2.4 Summary of the Lifetime Homes Standard's Applicability

Criteria	Provision	Interpretation/Compliance
1	Car parking width	Where there is car parking adjacent to the home, it should be capable of enlargement to attain 3300mm width.
2	Access from car Parking	The distance from the car parking space to the home should be kept to a minimum and access ways should be level or gently sloping.
3	Approach gradients	The approach to all entrances should be level or gently sloping.
4	External entrances	All entrances should be illuminated, have level access over the threshold; and main entrances should be covered.
5	Communal stairs and lifts	Communal stairs should provide easy access. Where homes are reached by a lift, it should be fully accessible.

Table 2.4 Summary of the Lifetime Homes Standard's Applicability (continue)

6	Doorways and hallways	The width of internal doorways and hallways should conform to Part M (Access and Use) of the English Building Regulations, except that when the approach is not head on and the hallway width is 900mm, the clear opening width should be 900mm rather than 800mm. There should be 300mm nib or wall space to the side of the leading edge of the doors on entrance level.
7	Wheelchair accessibility	There should be space for turning a wheelchair in dining areas and living rooms and adequate circulation space for wheelchairs elsewhere.
8	Living room	Living room should be at entrance level.
9	Entrance level bed space	There should be space on the entrance level that could be used as a convenient bed space.
10	Entrance level wheelchair and showing space	There should be a wheelchair accessible toilet at entrance level with drainage provision enabling a shower to be fitted in the future.
11	Bathroom and wheelchair walls	Walls in the bathroom and wheelchair should be capable of taking adaptations such as handrails.
12	Stair lift and though floor lift	The design should incorporate provision for a future: stair lift, and a suitably identified space for through the floor lift from the ground floor to the first floor.
13	Tracking hoist route	The design and specification should provide a reasonable route for a potential hoist from a main bedroom to the bathroom.

Table 2.4 Summary of the Lifetime Homes Standard's Applicability (continue)

14	Bathroom layout	The bathroom should be designed for ease of access to the bath, WC and wash basin.
15	Window specification	Living room window glazing should begin no higher than 800mm from the floor level and windows should be easy to open/operate.
16	Controls, fixtures and fittings	Switches, sockets, ventilation and service controls should be at a height usable by all (i.e. between 450 and 1200mm from the floor).

Table 2.4 Summary of the Lifetime Homes Standard's Applicability

Source: Assessing the cost of the Lifetime Homes standard (2012)

“The standards used in the study were published by the Habinteg Housing Association. If the department is to implement the Lifetime Homes concept as interpreted above it will need to issue clear guidance. The spirit of the standards should be to provide homes that fulfill the aspirations of modern living and are still adaptable and appropriate to changing needs.” (BCIS, 2012).

2.4 Concepts and Theories About Housing Design for Older People

Older people are those members of the population who are aged over 60 years. The majority of them are retired and have increased health/ medicine needs. According to projected data, by 2050 about 30% of Thailand's citizens will be over 60 years of age (World Population Review, 2019). In the field of architecture, there are many guidelines that define project management to better cater for people with special needs (Zupancic, 2014). Effective forward planning to help manage for the needs of the older population will in part combine social policies that are consistent with inclusive urban planning initiatives with targeted architectural design solutions to enhance wellbeing.

From the scope of the guidelines, they are able to define work areas as: design strategy and adaptation of existing build environments. The design-oriented part

meets those criteria: existing status, outdated; new design of the environment suitable for the latest building and to meet standards and high cost control. Design at its best is not just about good esthetics, it includes creative solutions for the economy, finance, and development, and tools to communicate with the local community. These steps form part of our adaptation to the integrated design process (Zupancic, 2014).

2.4.1 Design Environments to Include Older People and to be Inclusive

The debate about the aging population has focused on traditional issues such as health care, social security, and employee participation. However, now the focus has changed to what should be done within the built environment to support this age group through at various stages of old age (Bell, 2005). The environment planning and developing a variety of facilities can have a significant impact on the quality of life for the older people (Bell, 2005). Good planning and design can help people maintain a healthy lifestyle (Paduch, 2008). Measures can also be taken to help improve the health and wellbeing of individuals at all stages of their lives and nurture them whilst doing so.

Proper housing must be sought to meet the emotional, physical, and needs of individuals, and recognise networks connecting their history and lifestyle (Warnock et al., 2007). It needs to be inclusive by design. Proper planning will allow easy movement inside the house, its surroundings and nearby areas. It will also enable convenient access to transportation and services, and provide a safe and stimulating place within a good community, a place where people can live their lives, and build a sense and love of community, safe in the knowledge that it is their home for life (Warnock et al., 2007; Paduch, 2008).

In order to support and plan for the needs of older people, a number of initiatives have been developed to help solve age-related problems. Guidelines for solving the aging population problem should be designed on a flexible framework that: builds awareness within the local government of the aging population; encourages local governments to plan for their needs; promotes cooperation to support more collaborative methods to increase population inclusivity; and improves access to regional information about population growth and future demographic changes (Paduch, 2008).

2.5 Concepts and Theories about Building Design that Impact the Health, Wellbeing and Productivity of Occupants.

Biophilia

“The term ‘Biophilia’ refers to the (presently often forgotten) affiliation humans require with Nature and other species in order to truly thrive both physically and mentally” (Biosustainable Design, 2015). Too often architects, and others involved in the design of the built environment are unaware of this fact. Buildings need to be designed so that they can provide their users with better contact with nature (Figure 2.4).



Figure 2.4 Buildings can be designed to provide better contact with nature

Source: The Cà delle Alzaie project, Stefano Boeri Architetti and ‘The Green Villa’ by Dutch architecture, (2016)

It has already been shown that there is great economic benefit in creating closer connections with nature. The financial gain resultant from the provision of views

of nature to patients helps save helps save \$93 million/year in US alone (Browning, 2012). It has additionally been reported that patients who received surgery and have nature views have shorter hospital stays and require less medication, including less need for painkillers (Ulrich 1993, 1984).

In research by Kahn et al., (2008), an assessment was made of the restorative effect of view of a nature scene through a real window, as compared to a similar real-time view from a plasma TV screen mimicking a window or a blank wall. Those authors reported that the view through the real window was the more effective than the simulated real-time view in improving heart rate recovery from low-level stress. They also reported, as might be expected, that it was more effective in reducing stress levels than viewing a blank wall.

Tennessen & Cimprich (1995) report that the provision of views of nature from office settings results in workers having better directed attention. Similar was found for classroom settings, with students obtaining higher grades and also being more positive (Benfield et al., 2013).

The benefits to wellbeing of having plants indoors has also been investigated. Elzeyadi (2011) reported that in offices situations 10% of all absences were attributed to having no contact with nature, while Fjeld et al. (1998) reported that adding plants to offices resulted in a 14% reduction in absenteeism. Torpy (2014) additionally reported a 23% reduction in absences by children when plants were introduced in school areas.

Providing green space around buildings can also encourage individuals to become involved in outdoor gardening and urban agriculture, sometimes as individual activities and sometimes as community activities. These can have marked benefits to both fitness levels and health (University of Arkansas, 2000; Harvard Medical School, 2014).

As noted by Professor Tim Lang: “We can all benefit from gardening and community food-growing projects. ... extensive scientific literature that exists, examining the benefits of gardening and community food growing for both physical and mental health” (Garden Organic and Sustain, 2014).

There are numerous benefits available to the health and wellbeing of the population through providing smarter connections to nature within housing schemes. Additionally the fact that, as noted by Professor Joel B. Goldsteen, the provision of “... landscaping amenities pay back the developer as evidenced by the higher occupancies (and rents) clearly justifying the investment” also needs to be taken into consideration (Van Fleet, 1999).

Furthermore, it has been shown that the more environmentally rich an area is in terms of biodiversity the stronger the beneficial effects observed.



Figure 2.5 Stefano Boeri Architetti, Bosco Verticale building. Vertical Forest is a model for a sustainable residential building

Source: Divisare, (2018) Photo by: Giovanni Nardi



Figure 2.6 Daylight your home, the skylight Ideas to make your space brighter
Source: Sustainablehouseday, (2018)

As individuals spend so much of their time indoors. Most people spend the majority of their lives indoors (over 90% of their lives) And among the people who spend most of their time in the home are older generations. Therefore, it is extremely important to ensure that they breathe good quality air, receiving optimized light exposures, etc. to help maintain their health.

The impact of indoor environmental quality on health, well-being and productivity is an important matter to consider. This is because it can affect the health of users in positive or negative ways as related to health conditions such as asthma and respiratory allergies through low air quality, high or low temperature, excess humidity and insufficient ventilation and mental health such as depression and stress.

Through insufficient light ergonomic design (Baughman, 1996; Henneberger, 2005).

Therefore, in order to help individuals have good health, we need to concentrate more on how the design and operation of buildings may affect their occupants' wellbeing. This is a major research challenge, the findings of which could greatly aid the designers, occupants and operators of both residential and commercial buildings. Many studies refer to the effects of indoor environment quality on employee productivity and well-being (Lan, Lian & Pan, 2010) It has been shown that employees working in areas with poor indoor environmental quality tend to absent more often, waste more time and are less effective than those working in areas with high indoor environmental quality (Burton, et al., 2000; Ghodrati et al., 2012). Conversely, improved indoor environmental quality improves health and wellbeing. It is suggested that this holds true for those spending the majority of their time in dwellings as well.

2.5.1 Air Quality

The US EPA (2017) state that the benefits of measures to control outdoor air pollution can outweigh the costs of undertaking them by a ratio of at least three to one, and that the cost/benefit ratio could actually be as high as ninety to one.

From checking air quality in Thailand through the Air4Thai application of the Pollution Control Department, Thailand Air and AIR Quality, found that in many areas of Bangkok and many provinces have air quality covered by small particles, PM2.5, which affects health. AIR Quality reports air quality from 95 countries around the world. Found that Bangkok Ranked 19th in the world in which weather conditions affect health and if at the ASEAN level, Thailand is ranked in the 2nd place, where has the poor air quality that cause of bad effect on health (Thansettakij, 2020).



Figure 2.7 Bangkok air pollution, No Air No Air – Bangkok (Thailand) & Air Pollution
Source: my-thai, (2020)

Architecture and the areas surrounding buildings can all be designed to help reduce air pollution. An example of how effective this can be with buildings themselves is provided in the work of Pugh et al., (2012), who report that greening building roofs and facades can help improve air quality by reducing ambient NO₂ levels by up to 40% and concentrations of airborne particulate matter by up to 60%. Undertaking such initiatives creates numerous other benefits too.

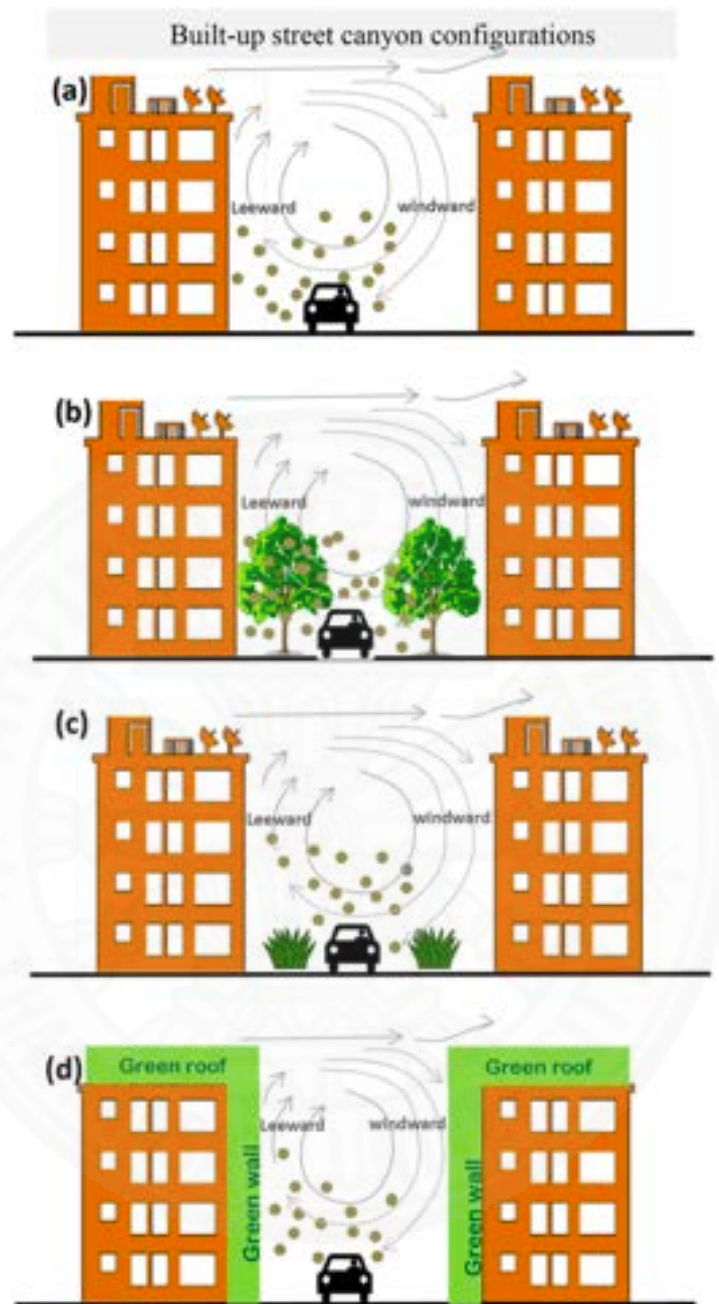


Figure 2.8 Description of flow and pollutant dispersion patterns in a street canyon with and without different types of vegetation: (a) vegetation free street canyon, (b) street canyon with trees, (c) street canyon with hedges, and (d) street canyon with green roof and green wall

Source: Abhijith, et al., (2017)

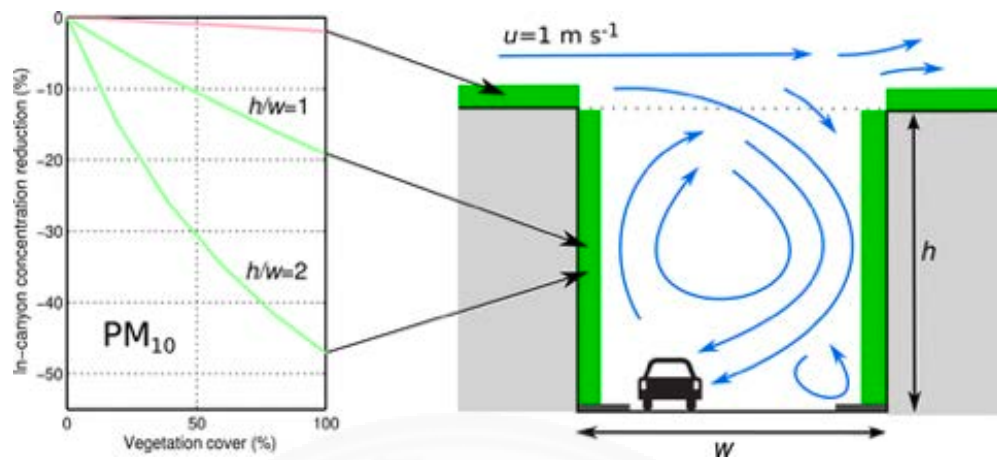


Figure 2.9 Green plants reduce city street pollution up to eight times more than previously believed

Source: Pugh et al., (2012)



Figure 2.10 Planeta-DeAgostini head office, a Spanish-Italian publisher in Barcelona, Green Energy News, “The people building a greener future” Image by: Getty Images

Source: Henryharrell, (2018)

2.5.1.1 Indoor Environmental Quality

(1) Indoor Air Quality

Indoor air has been defined as *"The air within a building occupied for a period of at least one hour by people in varying states of health"* (Laquatra et al., 2008).

Indoor air pollution is classified as chemical and biological pollutants that may affect occupants' health. These include: particulate matter (PM), volatile organic chemicals (VOCs), carbon monoxide (CO), carbon dioxide (CO₂), asbestos, radon, nitrogen oxides, construction chemicals, ozone. Biological contaminants include: mold, waste products of dust mites and cockroaches, endotoxins, houseplants, pollen (Hongxiang et al., 2004; IOM, 2000). Indoor air quality is one of the main environmental factors that can have effects on individuals' health, wellbeing and productivity (Ghodrati et al., 2012).

Research by Allen et al. (2016) has revealed that improving indoor air quality through design and enhancing ventilation to reduce CO₂ and air pollutant levels can substantially improve the cognitive performance of occupants. It is proposed that this fact should be taken into account, and acted upon, by those wishing to developing smarter lifetime homes that enhance wellbeing for all generations.

It has additionally been suggested that as the majority of PM_{2.5} particles are less than a micron in size, a size range for which electric fields can act as a major deposition mechanism, improved electromagnetic hygiene measures should also be adopted to reduce their concentrations within individual microenvironments. Research by Jamieson et al. (2010), and others, indicates that the presence of raised electric fields within such microenvironments, caused by the presence of poorly specified materials and/or electrical equipment, can increase local concentrations of airborne pathogens and other charged submicron contaminants (contaminants within the PM_{2.5} size range) in the air that people breathe and also the deposition of such contaminants on nearby surfaces thereby increasing the likelihood of ill-health.

The presence of raised electric fields within individual microenvironments in rooms can also reduce the local concentrations of biologically important small air ions (Figure 2.11), thereby further increasing the likelihood of reduced health, wellbeing and productivity (Jamieson et al., 2007). Measures can be taken to address this. One of these is the adoption of the Russian guidelines related to small air ion concentrations indoors (SanPiN, 2003) (Table 2.5). Other measures include the correct specifications of materials, so that high charges are not generated by actions that create friction.

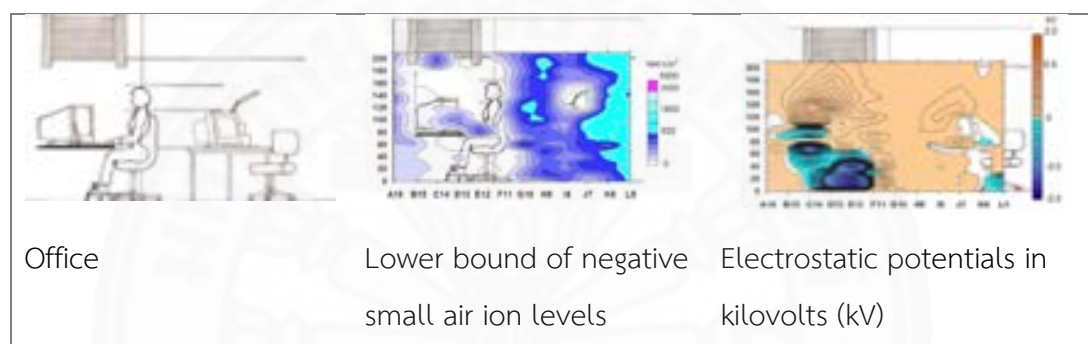


Figure 2.11 Vertical Section through Office Environment

Adapted from Jamieson et al., (2007)

Table 2.5 Russian Guidelines on mandatory bipolar small air ion exposures for computer areas

Concentrations	Negative small air ions / cm ³	Positive small air ions / cm ³
Minimum	600	400
Optimal	3,000 - 5,000	1,500 - 3,000
Maximum	50,000	50,000

Source: SanPin, (2003)

Small air ion levels can often be used to provide a good indication of the quality of the air.

- **Use of plants to help purify the air**

In addition to using general air purifiers and/or bi-polar air ionisers to improve the air quality in a dwelling, people can use plants to help both purify the

air and absorb dust. The cost of their installation and maintenance is often minimal and easily achievable by many. Furthermore, they can create other benefits to individuals in terms of biophilia, reducing building energy needs and helping reduce urban heat islands and global warming (Africa et al., 2019).

- **Plants as a means to clean the air**

Nowadays, most people think that the indoor environment will be a safe place from air pollution. Older individuals and children with respiratory problems are advised to stay at home during times of poor quality outdoor air. But from the study of Environmental Protection Agency (EPA) found today. Indoor air quality is poor and air pollution may be more than the level of outdoor air pollution more than 2-5, sometimes up to 100. According to studies, there are concerns that people may live in the building and receive quality air that is not good because the evaluation found that most people spend 90% of their time in the building (Wolverton Environmental Services, 2020).

NASA scientist Dr. Bill Wolverton at the John C. Stennis Space Center in Mississippi discovered that indoor plants were able to get rid of volatile organic chemicals (VOCs). To check the ability of plants that can be grown in Buildings to improve indoor air quality (IAQ), NASA has created a "Biohome" which has within it standard construction materials and synthetic decorations that can be the cause of continuous VOC emissions. According to the test, when walking into this building, there was a burning sensation in the eyes and throat and respiratory problems. After that, plants were placed that could grow indoors even in low-light environments. These were placed throughout the quarter to assess their ability to reduce VOCs. After that, re-evaluation by mass spectrometry/gas chromatography analysis showed that VOCs have decreased until they almost disappeared (Wolverton Environmental Services, 2020).

The use of plants indoors has become a growing trend in home decoration. When they are placed as part of the room, like furniture or props, they add beauty. The reason that vegetation can absorb pollutants in the air and purify air from dust refer to Table 2.6.

Table 2.6 Details of plants that can be used for improving the air quality







Plant	Picture	Benefits	Watering	Light	Moisture	Other
Xanadu Source: goodlifeupdate.com Image source: kaidee.com		Filter toxins and dust.	Needs medium water.	Likes sunshine .	Likes moisture.	Grows fast Likes loam.
Monstera Source: pueanry.co Image source: pueanry.co		Purify the air from dust. Absorbs various toxic substances.	Watered once every 2 days.	Likes sunshine .	Likes moisture.	Can be grown in an air conditioner room.
Snake plant Source: decor.mthai.com Image source: exoticflora.in		Dust filter Absorb various toxic substances Suction carbon, releasing oxygen.	Watered 2 times a week.	Likes sunshine .	Increase moisture to the room.	Can be placed in the bedroom.
Fiddle- leaf Fig Source: punpro.com Image source: believesourcing.co.th		Absorb various toxic substances Purify the air in the room.	Doesn't like a lot of water Can be watered 2 times a week.	Likes the sun (not intense)	Doesn't like moisture.	Hard to grow, slow to grow.
Sansevieria boncellensis Source: punpro.com Image source: lazada.co.th		Purify the air in the house.	Does not need much water.	Can stay in the shade.		Can stay in the shade Release oxygen at night.
Zanzibar Gem plant Source: punpro.com Image source: planterboxx.com		Air purification.	Watered 2 times a week.	Can stay in the shade.		Easy to care, rarely encountered weed problems.

Table 2.6 Details of plants that can be used for improving air quality (continue)

<p>Golden Pothos Source: postsod.com Image source: postsod.com</p>		<p>Helps to absorb ammonia.</p>	<p>Watered 2 times a week.</p>	<p>Needs a lot of sunlight.</p>	<p>Increase moisture to the room and like moisture.</p>	<p>Durable, easy to care.</p>
<p>Boston fern Source: baanlaesuan.com Image source: amazon.com</p>		<p>Detoxifies the dwelling. Removes formaldehyde well. Helps filter dust.</p>	<p>Needs a lot of water.</p>	<p>Likes sunshine .</p>	<p>Increase moisture in the air inside the building.</p>	<p>Likes cold weather.</p>
<p>Rubber plant Source: officemate.co.th Image source: katrinaleechambers.com</p>		<p>Removes formaldehyde well (Carcinogenic). Absorbs dust.</p>	<p>Watered 1 time per day.</p>	<p>Likes sunshine .</p>	<p>Like moisture.</p>	<p>Easy to grow.</p>
<p>Tillandsia usneoides Source: punpro.com Image source: th.nonilo.com</p>		<p>Helps filter dust Absorb heavy metal.</p>	<p>Needs a lot of water.</p>	<p>Likes sunshine .</p>	<p>Likes moisture.</p>	<p>Should be hung in a ventilated place.</p>
<p>Watermelon Dischidia Source: punpro.com Image source: baanlaesuan.com</p>		<p>Filters dust very well.</p>	<p>Need a lot of water.</p>	<p>Likes sunshine .</p>	<p>Likes moisture.</p>	<p>Easy to look after.</p>
<p>Aloe Vera Source: decor.mthai.com Image source: amazon.co.uk</p>		<p>Eliminates air pollution Absorbing formaldehyde which is irritating to the skin and eyes.</p>	<p>A little watering.</p>	<p>Likes sunshine .</p>	<p>Reduces dampness in the room.</p>	<p>Does not like wetness and coldness.</p>

Table 2.6 Details of plants that can be used for improving air quality (continue)

<p>Chinese evergreen</p> <p>Source: Today.line.me</p> <p>Image source: medthai.com</p>		Absorbs formaldehyde well (Carcinogenic).	Needs a lot of water.	Can grow even in the dark.	Increase moisture to the room.	Resistant to dry air.
<p>English Ivy</p> <p>Source: baanlaesuan.com</p> <p>Image source: housebeautiful.com</p>		Absorbs formaldehyde well, absorbs dust.	Needs a lot of water in the first period.	Needs a lot of sunlight.	Helps increase humidity in the atmosphere in the room.	This can be planted in the house by planting it in a pot with vertical frames.
<p>Urn plants</p> <p>Source: baanlaesuan.com</p> <p>Image source: homeidea.in.th</p>		Absorbs benzene, Absorbs chemical Eliminate volatile organic compounds.	Watered 2 times a week.	Likes sunshine .	Likes moisture.	Should be placed in an open area well ventilated with temperatures not over 35 degrees.
<p>Weeping fig</p> <p>Source: postsod.com</p> <p>Image source: postsod.com</p>		Absorbs benzene, absorb ammonia Toluene extractor.	Needs a lot of water.	Needs a lot of sunlight.	Likes moisture.	Likes loamy water well drained.
<p>Chrysanthemum</p> <p>Source: baanlaesuan.com</p> <p>Image source: sanook.com</p>		Helps filter out polluted air as well ex. Household paint, glue, plastic or even detergent substances.	Needs a lot of water.	Needs a lot of sunlight.	Increase moisture to the room and like moisture.	

Table 2.6 Details of plants that can be used for improving air quality (continue)








Arrowhead vine Source: decor.mthai.com Image source: pinterest.de		Able to absorb toxins and helps to purify the air in that area.	Needs medium water.	Likes sunshine .	Increase moisture to the room and like moisture.	Likes loam. Rarely encountered weed problems.
Peace lily Source: decor.mthai.com Image source: amazon.com		Absorbs Ammonia, alcohol, thinner, benzene and formaldehyde.	Needs medium water.	Can grow in the shade.	Increase moisture to the room.	Likes loam. Can be planted in the bedroom by the window, the balcony.
Orchid Source: Today.line.me Image source: lampsplus.com		Exhale oxygen and absorb carbon dioxide at night. Purifies the air.	Watered 2 times a week.	Likes sunshine .	Likes moisture.	Should not be watered too often Because it will cause the roots to become more moist than necessary.
Dwarf date palm Source: postsod.com Image source: postsod.com		Absorbs air pollution very well especially Xylene.	Needs a little watering.	Likes sunshine . Can grow in the shade.	Increase moisture to the room and like moisture.	Resistant to dry air.
King of hearts Source: today.line.me Image source: shopee.co.th		Absorbs ammonia.	Needs medium water.	Likes sunshine Can grow in the shade.	Likes moisture.	Likes the shade, Should use compost or manure mixed with water once a month.
Lily turf Source: today.line.me Image source: gardeningexpress.co.uk		Able to absorb ammonia toxic substances well.	Needs a little watering.	Likes sunshine		Likes loamy water well drained.

Table 2.6 Details of plants that can be used for improving air quality (continue)

<p>Yellow palm</p> <p>Source: today.line.me</p> <p>Image source: mgronline.com</p>		<p>Removes toxic substances from the air.</p>	<p>Watered 2 times a week.</p>	<p>Likes sunshine . Can grow in the shade.</p>	<p>Increase moisture to the room And like moisture.</p>	<p>Resistant to dry air.</p>
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(2) Temperature

During the period of 2008 to 2017, Thailand had an average annual temperature of approximately 27.1°C, with a general trend in temperature increases being indicated.

It has been observed that temperatures are generally increasing within cities, primarily because of the 'heat island effect' (Figure 2.12). The term "heat island" describes a built area that is warmer than nearby rural areas. The average annual air temperature in a city with 1 million occupants or more can be warmer than the surrounding temperature by around 1–3°C (1.8–5.4°F). In the evening, the difference can be as much as 12°C (22°F) greater. The heat island effect can affect communities by increasing peak energy demand during the hot season, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illnesses and deaths, and water pollution (U.S. EPA, 2020).

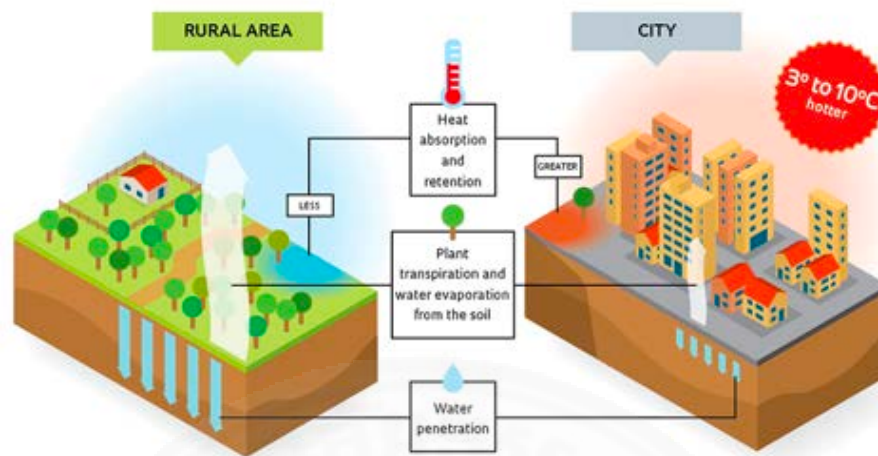


Figure 2.12 More cities are or will be at risk of extreme heat because of climate change and increased urban development

Source: ecori, (2019)

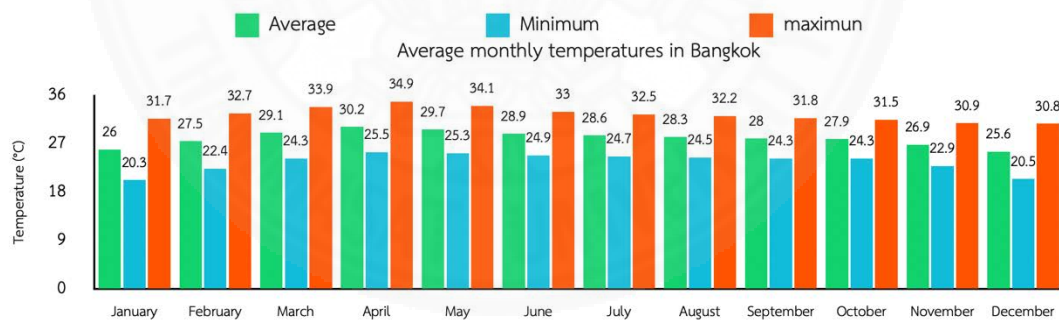


Figure 2.13 Average monthly temperature in Bangkok

Source: Climate_Data.Org, (2020)

It has been predicted that worldwide that this situation could double climate change costs for some cities (University of Sussex, 2017). An indication of the range of temperatures that can be experienced in Bangkok throughout the year is provided in Figure 2.13 and throughout the 10 years is provided in Figure 2.14.

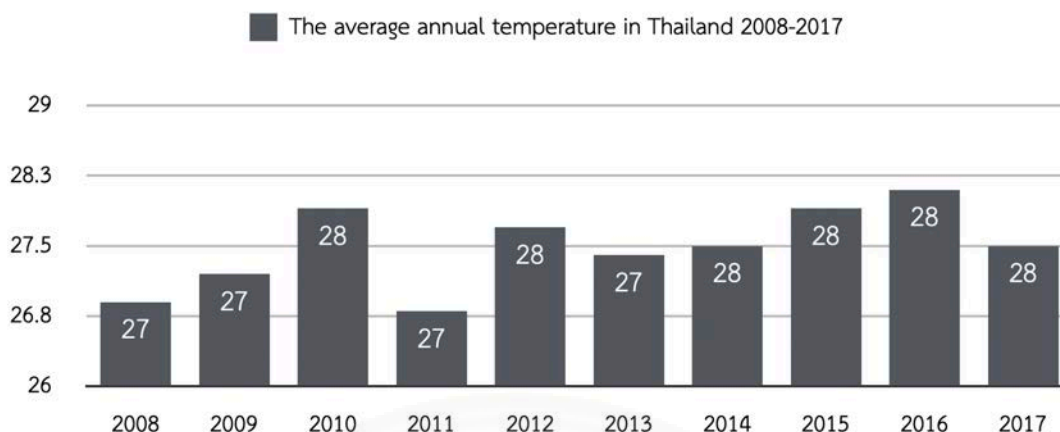


Figure 2.14 The average annual temperature in Thailand 2008-2017

Source: Thai Meteorological Department, (2018)

The temperatures experienced in Bangkok are usually higher than those experienced elsewhere in Thailand due to the urban heat island effect. A number of detrimental health effects have already been observed to be on the increase in Bangkok as a result of its growing urban heat island (Chayapong & Dasananda, 2012, Arifwidodo & Chandrasiri, 2016) (Figure 2.15)

Bangkok & its satellite provinces

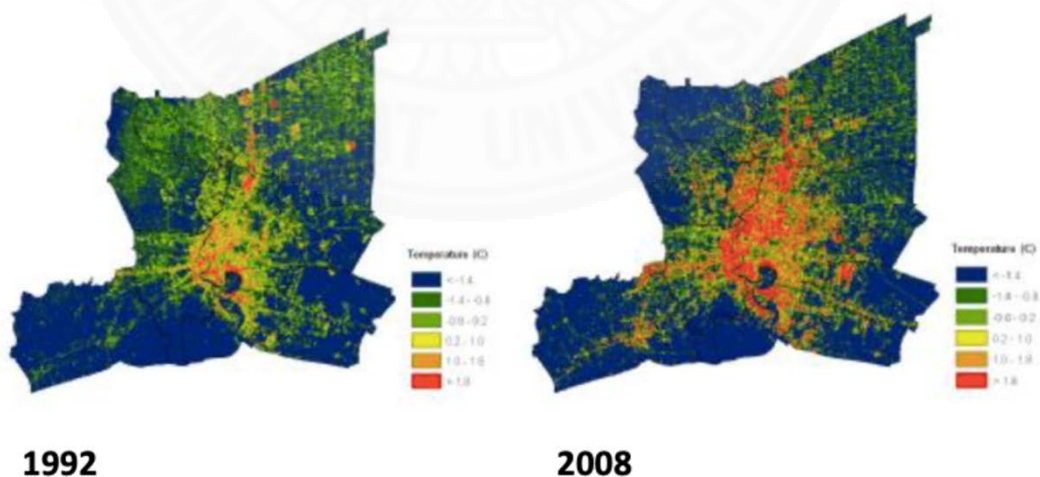


Figure 2.15 The urban heat island created by Bangkok & its satellite provinces is growing

Source: Chayapong & Dasananda, (2012)

These health effects include increased cases of: reduced activity during hot periods; cardiopulmonary disease; cerebrovascular disease; chronic bronchitis, pneumonia; heat stress; ischemic heart disease; reduced mobility; higher sedentary behaviour; respiratory disease: influenza, common cold; and sleep deprivation (Arifwidodo & Chandrasiri, 2016). Excessive temperatures can also increase allergy and reduce occupant satisfaction, productivity and wellbeing (Ghodrati et al., 2012). It is proposed that the provision of extra green space within the design of built environment can help reverse such temperature increases (Figure 2.16).



Figure 2.16 Comparison of heat signatures of green and conventional roofs, (n.d.)

Sleep deprivation, as in part brought about by sleeping in a room that is too hot, can substantially affect overall wellbeing and can increase risk of: accidents (Institute of Medicine, 2006); neurological problems, including Alzheimer's disease and other dementias (Di Meo et al., 2014); pain and pain-related conditions in adults over 50 (Jegtvig, 2014); depression and anxiety (Krystal, 2012); heart disease (Neighmond, 2015); impaired learning ability (Paddock, 2016); and impaired immune response (Besedovsky et al., 2012). Additionally, individuals with chronic insomnia have a three times higher risk of death from any cause than those without insomnia (American Academy of Sleep Medicine, (2010).

In order to try to improve sleep quality, it is important to know what the ideal temperature range for bedrooms are to aid recuperative sleep. A number of studies suggest that the optimum temperature for sleep is often quite low (Table 2.7), between 15°C and 22°C. Onen et al., (1994) note that the longest total

sleep times arise within the zone of thermoneutrality, with sleep time and sleep quality both decreasing for temperatures above and below that range. Those authors further note that thermoneutrality is achieved at an environmental temperature of 30-32°C when individuals do not wear pyjamas, and 16-19°C when wearing pyjamas and covered with at least one sheet. Such factors are useful to note when seeking to optimise the biological effects of design decisions and also help reduce energy usage.

Table 2.7 Average optimum temperature ranges for individuals, Influence on Human Sleep Patterns of Lowering and Delaying the Minimum Core Body Temperature

Average optimum temperature ranges for individuals	
Age	Temperature
Adults	15-22°C
Babies/Toddlers	18-21°C
Older individuals	19-21°C

Source: National Center for Biotechnology Information, (2007)

Additionally, since heat rises, designing for bedrooms to be located on a lower floor would additionally help cool them. Having older people have all their main accommodation on a single level at a low level in the building would also help with regards to this, as would dwellings have the optimum amount of insulation.

Indoor temperature is an essential factor that strongly impacts user wellbeing, alongside air quality, and can also have a direct impact on the levels of biological pollution experienced. According to Nielsen (2002), temperature plays an important role in the growth of indoor molds - as can humidity levels. Indoor temperatures can also affect off-gassing from construction and decorative materials.

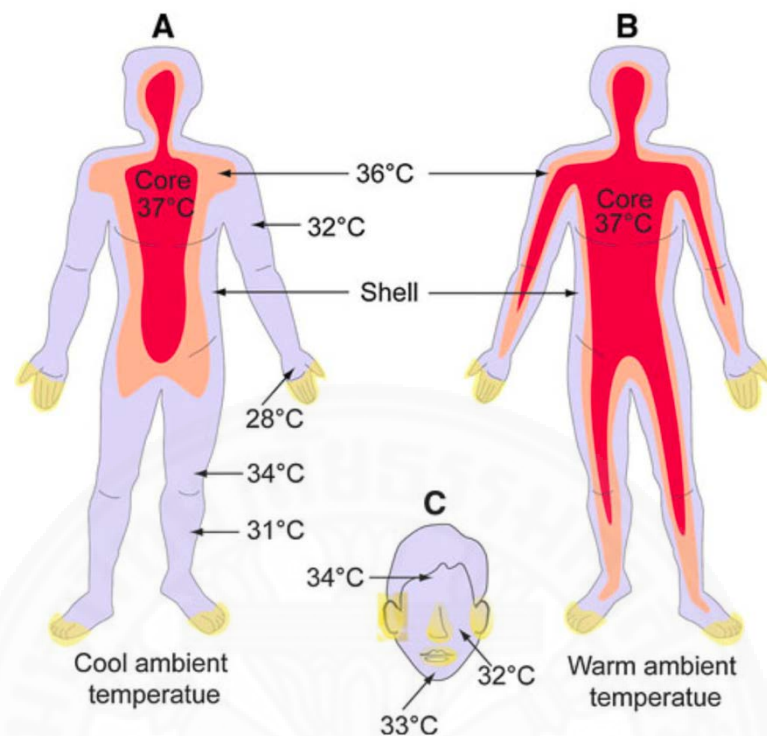


Figure 2.17 Human body temperature

Source: Chayapong & Dasananda, (2012)

(3) Humidity

Both high and low humidity levels can adversely affect can affect residents' health, with inappropriate exposures can increases the likelihood of respiratory illness and other health problems (Sterling et al., 1985; Rieset al., 2007; Jamieson et al., 2010). Therefore, the optimisation of humidity levels is important for indoor air quality and the thermal satisfaction of residents (Ghodrati et al., 2012).

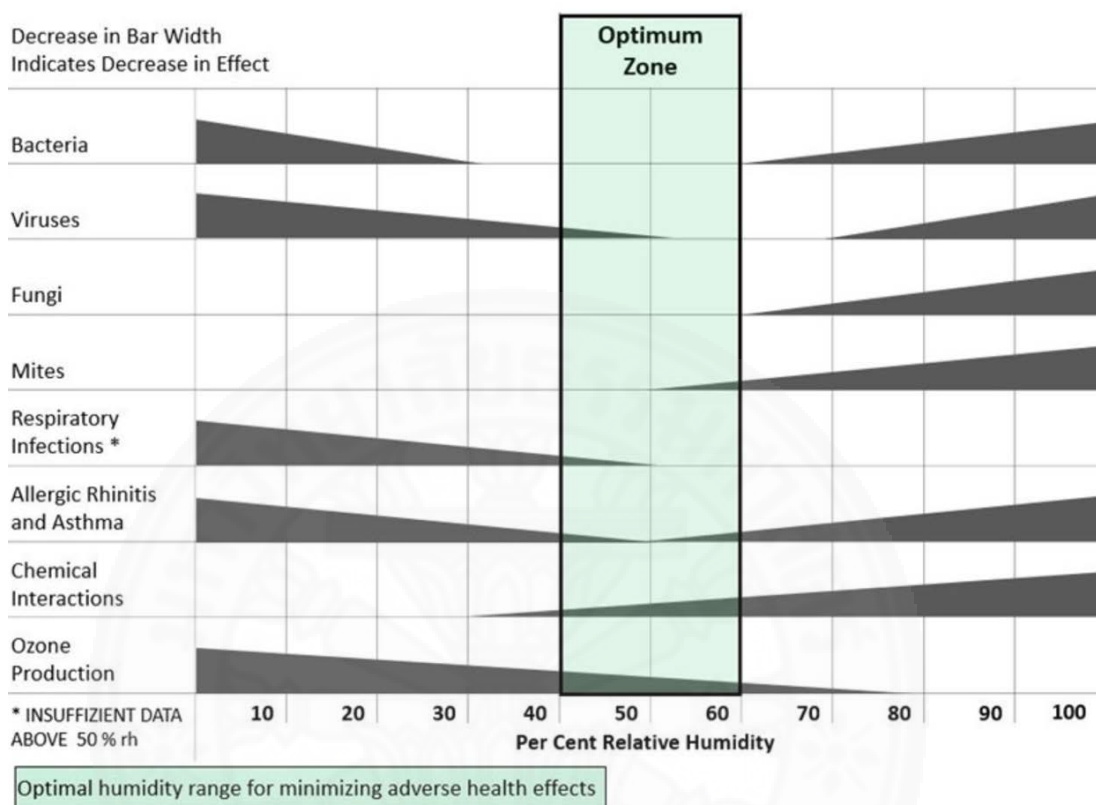


Figure 2.18 Optimising Relative Humidity to help Improve Biological Functioning
Source: Sterling et al., (1985)

Jamieson et al., (2007/2010) suggest that, in terms of best practice, it is better to use dewpoint temperature instead of relative humidity as an indicator of the amount of water in the air. They further propose 12°C dewpoint temperature as an ideal average dewpoint temperature to use indoors to reduce the generation of electrostatic charge and the deposition of airborne pathogens.

(4) Ventilation / Air Quality

Effective and efficient ventilation helps improve indoor air quality and occupant's satisfaction with comfortable temperatures, and reduce the negative impact on the health and well-being of occupants. The air supplied may

come from the outside of the building, and may require filtration to avoid/reduce outdoor pollution entering the building (Ghodrati et al., 2012).

- **Indoor Air quality**

Indoor air often contains contaminants. There are three main types of air pollution in buildings.

Types of indoor air pollution:

1) Emissions from combustion of solid fuels caused by burning wood, coal or other solid fuels such as burns from cooking which these dust causes pollution in the air. If inhaled, it may cause health effects such as stroke, pneumonia, lung cancer and heart disease (World Green Building Council, 2016-2020).

2) Biological contaminants caused by the air that can penetrate from the cracks in the building's wall. Causing moisture in the air which leads to the growth of mold in the air. Adversely affecting health makes the risk of asthma as high as 40% (World Green Building Council, 2016-2020).

3) Volatile organic compounds (VOCs) Volatile substances released from general products both solid and liquid which can adversely affect health. There may be headaches, nausea and, moreover, may result in the risk and suspect link to cancer that is harmful to health (World Green Building Council, 2016-2020).

Causes of indoor air pollution

- Poor ventilation
- Furnishings
- Toxic building materials
- Occupier activities
- The relationship between outdoor and indoor pollution

With regard to international standards, there are many organisations that have set indoor air quality standards. Commonly used indoor air quality standards in Thailand are the ASHRAE Standard 62-1989 Ventilation for

Acceptable Indoor Air Quality of USEPA United States of America and the SS554: 2009 Code of Practice for Indoor Air Quality for Air-Conditioned Buildings SPRING Singapore. As SPRING Singapore was developed in an area with similar weather to Thailand, its use is recommended by the Thai Bureau of Occupational and Environmental Disease (2018) (Table 2.8).

Table 2.8 Indoor air quality standard standards of SPRING Singapore

Air quality factors	Recommended value
Thermal comfort conditions	
Temperature	20-26 °C
Relative Humidity	50-65 %
Air Movement	0.1-0.3 m/s
Ventilation	2-10 m ³ /hr/m ²
Indoor air pollution	
Carbon dioxide	< 700 ppm.
Carbon monoxide	< 9 ppm.
Particulate Matter with diameter less than 2.5 micrometers: PM _{2.5}	< 35 µg/m ³
Particulate Matter with diameter less than 10 micrometers: PM ₁₀	< 50 µg/m ³
Ozone	< 0.1 ppm.
Formaldehyde	< 0.1 ppm.
Volatile Organic Compounds: VOCs	< 3 ppm.
Fungii	< 500 CFU/m ³
Bacteria	< 500 CFU/m ³

Source: Buildings SPRING Singapore, (2009)

In order to better provide comfort and safety, exposure to air pollution, including airborne pathogens, must be reduced.

- **Improved air quality and mental functioning**

Research investigating how exposure to better indoor air quality might improve the higher-order cognitive mental functioning of office workers

was undertaken by Allen et al., (2016). They were able to demonstrate that improving air quality, as related to CO₂, Volatile Organic Compound (VOC) and ventilation levels over that found in standard ‘conventional’ environments, can substantially improve cognitive performance, with average cognitive performance scores in the green office indoor environment they assessed being 61% higher than for standard ‘conventional’ offices.

It is proposed that similar benefits may be achievable with regards to the mental functioning of individuals living in dwellings where they receive higher quality air to breathe.

(5) Noise

“Noise complaints top the list of complaints lodged by the public across the country, according to new research funded by the Thailand Research Fund (TRF)” (Bangkok Post, 2018).

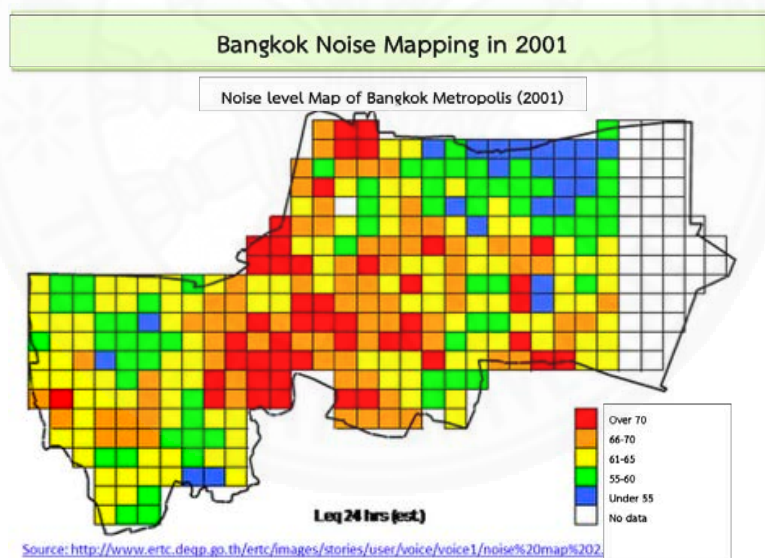


Figure 2.19 Bangkok noise mapping in 2001

Source: research.chula.ac.th, (2001)

Health effects resultant from exposure to noise pollution include: mortality; disease sleep disturbance, cardiovascular disorders (hypertension and ischaemic heart disease), tinnitus; risk factors (blood clotting, blood pressure, cholesterol, glucose); stress indicators (autonomous response, stress hormone

changes); feelings of discomfort (annoyance, disturbance); cognitive impairment (including children's cognition as a result of chronic noise exposure) (WHO, 2011) (Figure 2.19). Cognitive decline is also associated with exposure to noise pollution (Fong, 2014).

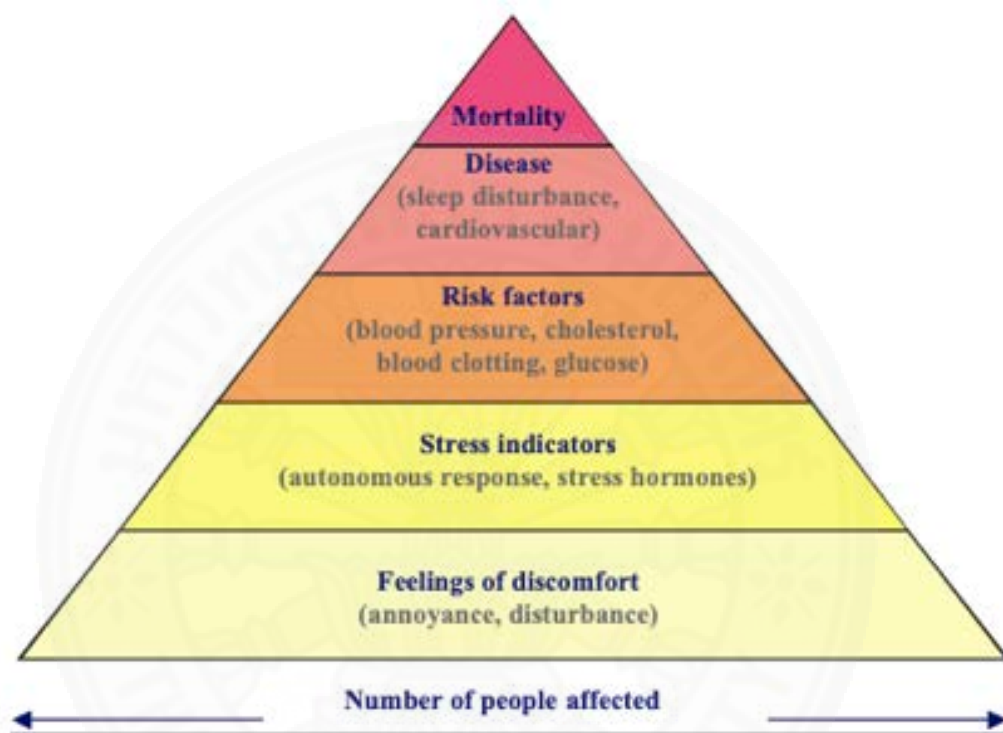


Figure 2.20 Severity of health effects from noise exposure and number of individuals affected

Source: WHO (2011)

The noise levels individuals are exposed to can have significant impacts on their wellbeing. As examples, a UK study indicated that costs of exposures to daytime noise levels of ≥ 55 dB(A), which may be responsible for additional individual cases of people with hypertension-related myocardial infarction, stroke, and dementia, may be as high as £1.09 billion per year (Harding et al., 2013).

Other outcomes related to environmental sounds have been suggested, including hearing impairment, psychiatric conditions such as depression and anxiety, the effects of next-day sleep disturbances such as car accidents (WHO, 2011).

Long-term exposure to loud noise can lead to hearing loss and permanent damage to individuals' hearing. Personal motivation to accomplish tasks is also reduced under noisy conditions. Noise pollution negatively impacts the efficiency, effectiveness and wellbeing of individuals in many different ways (Evans et al., 2004; Ghodrati et al., 2012). Risk increases as noise levels increase. As an example, the meta-analysis by van Kempen & Babisch (2012), which investigated the quantitative relationship existing between hypertension and traffic noise, reported a 3.4% greater probability of prevalent hypertension for every 5 dB increase in road traffic noise.

Finlay et al. (2012) note that acoustic privacy, from both indoor and outdoor sources of noise, is an important element in improving building quality and one that can be readily achieved through improved design measures that can both reduce noise and improve thermal insulation. Those authors noted that home buyers could see the importance of such measures being taken but only after they were prompted to do so.

Noise pollution can negatively impact individuals whilst they are living at their own properties. Domestic buildings, their surroundings, and in particular the rooms in which individuals sleep, can be better designed to help provide improved levels of sound insulation to better protect occupants from noise pollution from external sources.

(6) Exposure to Natural and Artificial Light

Individuals often suffer from 'mal-illumination' being exposed to the wrong levels and spectra of light at the wrong time of day. The creation of biologically appropriate exposures to daylight and artificial light are little considered within standard architectural design. Neither is the biological importance of being able to sleep in darkness. Additionally, many lighting systems presently in use are often not designed to take into account the effects of exposure to different light spectra on biological functioning, psychological performance and wellbeing.

• Light exposures

Daylight should ideally be used as the main light source in buildings during the day to help fulfill individual's visual and biological needs.

Outdoors in full Sunlight, light levels of over 100,000 lux can be measured. In full daylight out of the direct sun exposures of over 10,000 lux can arise (The Engineering ToolBox, 2014). Animal tests have revealed that 30-minute daily exposures to light levels of 10,000 lux are associated with significantly reduced risks of heart attacks (Oyama et al., 2019).

When measured indoors directly next a window, the available light can be just over 1,000 lux (Adams, 2019). Natural light levels can often be substantially reduced indoors especially towards the back of rooms and corridors, often necessitating the use both natural and artificial light during the daytime in some situations. Additionally, with regards to light exposures, there is the situation often experienced in Thailand where people will deliberately draw curtains and blinds to avoid exposure to natural daylight.

“Daylighting should be designed to provide adequate light levels in the room and on the work plane so that daylight is the main/or only source of light (autonomous) during daytime” NARM (2019).

- **Lighting levels indoors**

In Thailand, a minimum illuminance level of 100 lux is required for residential properties (TIEA, 2003; Chaiyakul, 2005). In other countries the requirements stipulate higher levels. Table 2.9 provides a listing of minimum lighting levels for residential spaces (Adams, 2019).

Table 2.9 A listing of minimum lighting levels for residential spaces.

Room	Type	Recommended light levels
Kitchen	General	300 lux
	Countertop	750 lux
Bedroom (adult)	General	100-300 lux
	Task	500 lux
Bedroom (child)	General	500 lux
	Task	800 lux
Bathroom	General	300 lux
	Shave/ makeup	300-700 lux

Table 2.9 A listing of minimum lighting levels for residential spaces (continue)

Living room	General	300 lux
	Task	500 lux
Family room/ home theater	General	300 lux
	Task	500 lux
	TV viewing	150 lux
Laundry/ utility	General	200 lux
Dining room	General	200 lux
Hall, Landing/ stairway	General	100-500 lux
Home office	General	500 lux
	Task	800 lux
Workshop	General	800 lux
	Task	1,100 lux

Source: Adams, (2019)

Lighting can have a dramatic impact on the quality of the indoor environment. It affects both the physical and mental wellbeing of occupants. It can also affect individual's levels of comfort, safety, fatigue, and productivity (Hwang et al., 2011). Poorly lit environments can cause symptoms such as allergic reactions, dry eyes, headaches, and eye fatigue. They can also affect learning performance (Boyce, 2010).

It has been shown that exposing children to higher light levels, 500 lux compared to 300 lux, can help improve their reading grades (Govén et al. 2010). It has also been shown that receiving higher levels of daylight exposures is associated with obtaining improved academic results (Heschong Mahone Group, 2015).

Furthermore, it has been reported that when individuals are in light, spacious environments they feel increased levels of enthusiasm, creativity and productivity (Human Spaces 2014). It has also been reported that higher levels of daylight exposure are associated with improved memory recall, mental function and task performance (Loftness et al., 2009). All factors that can lead to increased feelings of wellbeing for all generations and that can be encouraged through the smarter design of lifetime dwellings.

Green buildings use as much light from the Sun as possible to:

- Reduce energy usage.
- Provide a comfortable environment for occupants.

Suitable lighting provision in green buildings combining the best methods of natural and artificial lighting not only improve the health and satisfaction of occupants but also improve their work efficiency and productivity (Ghodrati et al., 2012). Factors worth being aware of, especially as more people are starting to work from home. Even smarter, more biologically-friendly, lighting exposures can be created.

“Most people prefer to work in natural daylight, and should be able to do so whenever possible. Other aspects of lighting which can have a bearing on SBS are inadequate lighting levels, glare, very uniform artificial lighting, dull decor and tinted glass windows. These features should be avoided where practicable” (UK Health and Safety Executive, 1992). The use of tinted windows can negatively impact health and wellbeing, as can the types of artificial lighting they are exposed to. So when tinted glass is to be used, only neutral grey tints should be specified (Ott, 1973).

• **Mal-illumination and possible life expectancy**

As an indication of how serious the issue of mal-illumination is, mention is made of the work undertaken by Ott (1973) which revealed that the type of light exposures test-animals received could greatly influence their longevity (Figure 2.21). The effects of exposure to different types of lighting, which were assessed for a cancer-prone breed of mouse, revealed the following average life-spans under the scenarios tested: Air curtain exposures, i.e. the test-mice received natural unfiltered daylight: 16.1 months; Full-spectrum glazing: 15.6 months, Standard ‘clear’ window glass which strongly filters some light wavelengths: 9.4 months; Daylight fluorescent artificial light: 8.2 months: and Pink fluorescent: 7.5 months. The mice receiving the most natural light exposures were shown to live twice as long as those receiving the worst exposures!

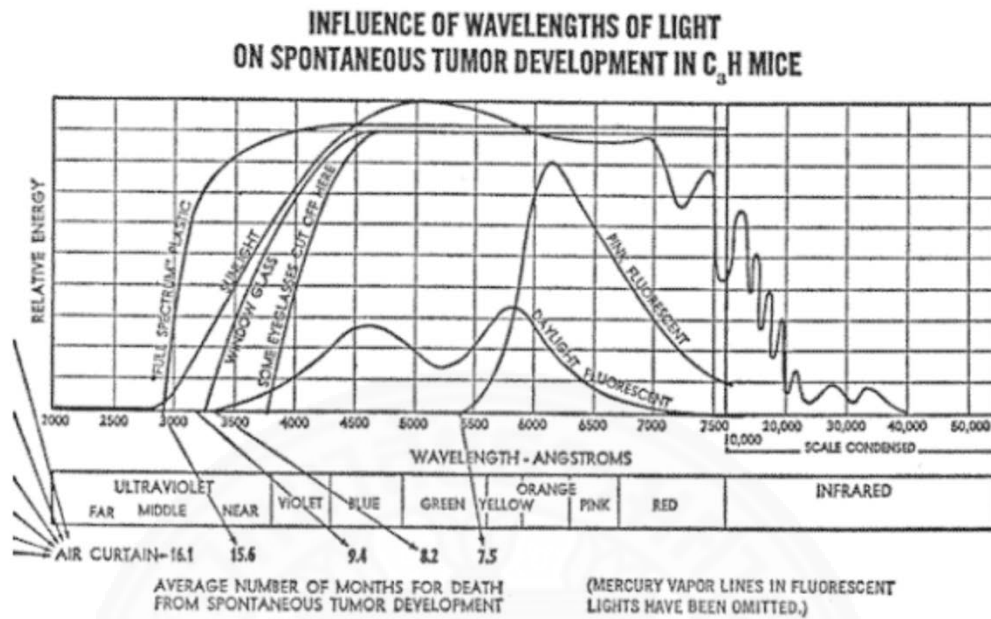


Figure 2.21 Influence of wavelengths of light on spontaneous tumor development

Source: Ott, (1973)

- **Exposures to light during daytime and nighttime**

The time of day individuals experience particular light exposures can also have significant effects on both their short and long-term health. It is particularly important to design environments so that individuals can, ideally, get good exposure to daylight during the day and minimal exposure to light at night. As an example of how this can be achieved by optimising design layout, refer to Figure 2.22.



Figure 2.22 Standard and revised floor plan, indicating how design layout can be used to help optimize light exposures and biological functioning

Source: Jamieson, (2019)

In the standard floor plan shown in Figure 2.22, individuals occupying the living area get very little exposure to natural daylight. With such layouts, it is also highly likely that room curtains will be drawn during daytime further cutting down on beneficial light exposure. At night-time, the placement of the bed near the window will increase individuals' exposures to light from outside – particularly as few curtains are designed to be 'light-tight' or act as blackout curtaining. The revised layout, helps promote exposure to higher levels of daylight and also less exposure to light at night. The revised design has also sought to increase occupants' exposure to greenery, as this too has been found to help increase wellbeing.

Measures can also be taken to ensure that design features such as balconies are better used in order to help increase occupants' exposure to daylight. One way of doing this is to ensure that balconies are of the right size and proportion to encourage this.

Furthermore, with regards to the time of day individuals receive strong daylight exposures and wellbeing, research has shown that patients in southeast

facing rooms (receiving early morning sun) have shorter recovery times than patients in rooms that face northwest (Choi et al. 2012). This indicates that when undertaking smarter building design, the orientation of bedrooms should also be taken into consideration when seeking to biologically optimise individual's biological performance (Jamieson, 2019).

- **Light exposures at night**

Individuals generally receive far higher exposures to light at night than they should, often as a result of light pollution from outdoors. Light pollution at night is on the increase in many parts of the world, and measures should be taken to guard against it. Ideally, individuals should be able to sleep in complete darkness, No Light At Night (NOLAN) conditions, during the nighttime. Often bedrooms are not designed in ways that allow this to be easily achieved. Additionally, the type of light exposures that individuals receive at night can have marked impacts on their health.

As examples, research indicates that there is increased risk of breast and prostate and breast cancers in individuals who receive relatively high exposures to blue light at night (Garcia-Saenz et al. 2018). Furthermore, even relatively low exposures to artificial light during sleep are associated with health problems. As examples, Obayashi et al., (2018) report that exposures to light of ≥ 5 lux when sleeping is associated with increased risk of depression risk, and (Obayashi et al., 2016) notes that exposure to levels ≥ 3 lux are associated with likelihood of obesity.

National Health Commission, Office of Health Promotion Fund and Institute for Population and Social Research Mahidol University disclosed "Thai Health Report 2014" reflecting the major health threats this year is the "obesity" that is currently undermining the health of Thai people. Thai Health Report 2014, found that Thai people have doubled their weight in 2 decades, compared to 10 Asian countries. Thai men ranked 4th, women ranked 2nd, leading to chronic diseases while Bangkok people are more at risk of obesity than people in other provinces. Thai people's health report 2014 states that obesity is considered as the cause of illness and death before a reasonable date. From chronic non-communicable diseases (NCDs) such as diabetes, high blood pressure, liver disease, cancer, gallbladder disease, depression, difficulty

breathing and sleep apnea. And osteoarthritis, etc., in which obese people are 2-3 times more likely to have these diseases (Nokdee, 2014).

In addition, obesity in Thailand. It is likely to expand further in the future. According to a survey of Thai people's health by physical examination in 2009, more than a third of Thai people aged 15 years or older are in double overweight and obese conditions. Compared to the last 2 decades (1991-2009) and if compared at the regional level found Thai people are the 2nd highest in 10 out of 10 ASEAN countries (Nokdee, 2014).

At the same time, obese children are still found, from early childhood (ages 1-5) and school age (ages 6-14), growing to a point of concern. Every 10 school children will find at least 1 person who is overweight and obese. Violence varies from region to region. Increase according to the level of development and economic status with the highest rate is being in the area Bangkok and the lowest is in the northeast (Nokdee, 2014).

(7) Electromagnetic Hygiene / Bioelectromagnetic Design

“Until relatively recently, all life evolved exclusively under changing cyclic exposures to natural sources of visible light, static and time-varying natural electric, magnetic and electromagnetic fields of terrestrial and extra-terrestrial origin. All of these can provide important biological cues and information. With increased knowledge of how life forms react to exposure to such phenomena and manmade electromagnetic radiation (EMR), alongside the application of best practice measures to reduce electromagnetic pollution and optimize the electromagnetic nature of environments, a far more sustainable, exciting and economically viable future is now starting to evolve.” (Jamieson, n.d.)

In 1809, the first electric light was invented (Sonneborn., 2007). Seventy-one years later, in 1880, the world's first wireless transmission was sent in Washington D.C. (Jamieson, 2010), and two years later that, in 1882, New York's Pearl Street Generating Station in New York became the world's first permanent electric power plant (Sulzberger 2013). Since those times, the presence of manmade electromagnetic radiation in the environment has increased exponentially. Exposure

guidelines vary tremendously between countries with some being very more stringent than others (Jamieson, 2014) (Figure 2.23). Thailand presently adheres to the ICNIRP guidelines often advocated by industry. It has been reasoned by many building biologists and scientific experts that more stringent guidelines than ICNIRP's are required (BioInitiative Working Group, 2012).

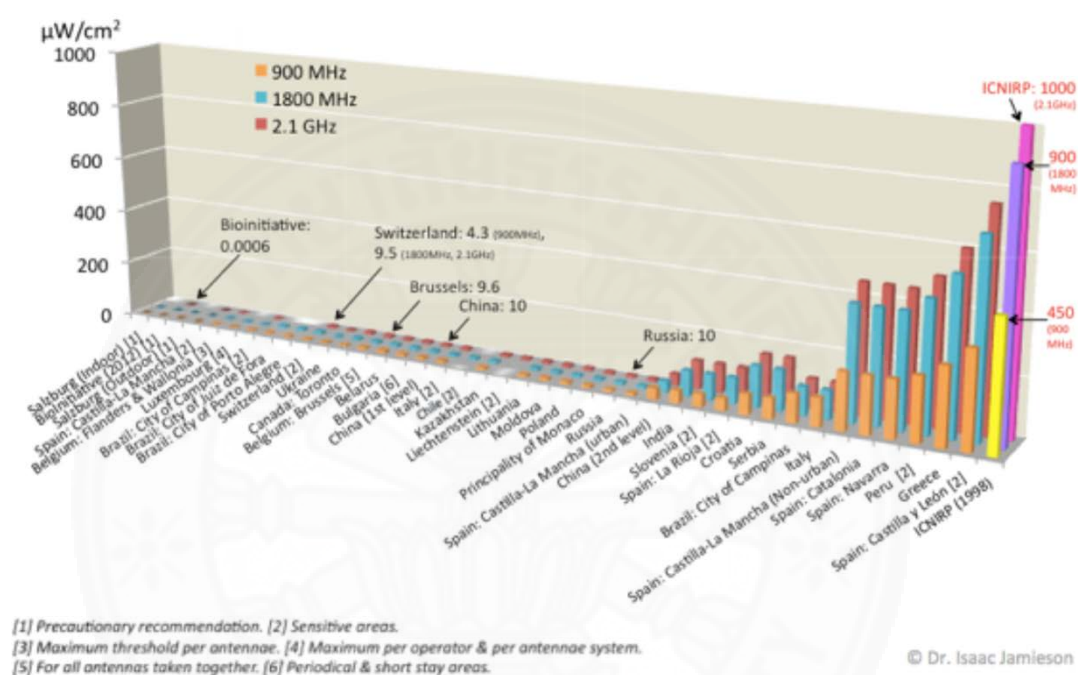


Figure 2.23 Radio frequency EMF legal exposures & non-binding recommendations

Source: Jamieson, (2014)

It is important while discussing this topic to mention the findings of research disclosed by China's Center for Disease Control and Prevention to the World Health Organization in 2007. In that work, it was reported that in 108 out of 109 of epidemiological studies conducted in China from 1994 to 2006, biological effects of EMF exposure were observed on people's health. It further stated that: "No matter what the exposure level may be, lower or higher than EMF exposure limits for public, health effects had been reported in these papers." Among the health effects reported were: abnormal electrical activity of the heart; immunoglobulin disorders; miscarriage; neurasthenia; poor sleep quality; and sperm dysfunction (Cao, 2007). The Chinese exposure limits are shown in Table 2.10.

Table 2.10 General Public Exposure Limits to RF/microwave radiation in China

Frequency	1st class exposure limits	2nd class exposure limits
0.1-30 MHz	10 V/m	25 V/m
>30-300 MHz	5 V/m	12 V/m
>0.3-300 GHz	10 microwatts / cm ² ($\mu\text{W}/\text{cm}^2$)	40 $\mu\text{W}/\text{cm}^2$
<p>1st class exposure limits: Exposures below these levels thought to be safe for permanent exposure and all people (including infants, pregnant mothers, patients, older people, etc.).</p> <p>2nd class exposure limits: Exposures below these levels acceptable for short-term exposures (factories, parks, recreation spaces, etc.). Living quarters, hospitals, schools, kindergartens, etc., not allowed to receive such exposures.</p>		

Source: Chiang, (2009)

As mentioned at the beginning of this thesis, Thailand is rapidly moving towards becoming an ‘aged’ society. Part of the reason for this is its fertility rate having decreased from 6.6 to 2.2 over the last 2 decades (Towie et al., 2019). The possibility exists that one of the contributing factors to that decline may be the raised electromagnetic field exposures individuals receive when using wireless devices, or being in close proximity to wireless emitters in the built environment. Tests on animals by Magras & Zenos (1997) showed irreversible infertility in mice after three generations at radiofrequency exposures of only $1.053 \mu\text{W}/\text{cm}^2$, with even lower exposures of just $0.168 \mu\text{W}/\text{cm}^2$ linked with total infertility of mice after five generations.

Research on humans has also revealed that exposure to radiofrequency radiation may be contributing to drops in fertility levels. As examples, significant decreases in sperm motility and increases sperm DNA fragmentation have been observed in test-subjects exposed to electromagnetic fields (EMFs) from active Wi-Fi connected laptop computers. DNA fragmentation is associated with reduced levels of fertilisation, reduced embryo quality, miscarriage and increased illness in offspring (Aitken & De luliis, 2007).

As noted by Jamieson & Mallery-Blythe (2015): “There is clear evidence of subsections of the general population such as: children, pregnant women and those with electromagnetic hypersensitivity sensitivity (EHS) being more adversely affected by exposure to electromagnetic pollution.” One of the challenges of smarter design is to seek to ensure that healthier electromagnetic environments and technologies are created.

- **Inclusive bioelectromagnetic design**

It is worth reinforcing the point that there is a need to ensure that smarter lifetime homes that are designed to enhance wellbeing for all generations need to be inclusive. This means that they also need to cater for the needs of individuals who are electrohypersensitive (EHS) (Figure 2.24). Depending on the nation, between 1-10% of individuals may be EHS (Hallberg & Oberfeld, 2006). Many others may be affected to various degrees by electromagnetic pollution.



Figure 2.24 People who are EHS need to have inclusive bio-friendly environments created for them

Image and video clip: *Desperately seeking white zone* (Trailer) (2014),

Source: <https://www.youtube.com/watch?v=PSK7ciWMFmE>

As observed by the US National Institute of Building Sciences (NIBS, 2005): “For people who are electromagnetically sensitive, the presence of cell

phones and towers, portable telephones, computers, fluorescent lighting, unshielded transformers and wiring, battery re-chargers, wireless devices, security and scanning equipment, microwave ovens, electric ranges and numerous other electrical appliances can make a building inaccessible. ... the Committee recommends that measures be taken to reduce EMF whenever possible in order to increase access for these individuals as well as taking a precautionary approach to protecting the health of all.”

- **Electromagnetic pollution and bioelectromagnetic design**

Nowadays, most people think that the indoor environment will be a safe place from air pollution. Older individuals and children with respiratory problems are advised to stay at home during times of poor quality outdoor air. But from the study of Environmental Protection Agency (EPA) found today. Indoor air quality is poor and air pollution may be more than the level of outdoor air pollution more than 2-5, sometimes up to 100. According to studies, there are concerns that people may live in the building and receive quality air that is not good because the evaluation found that most people spend 90% of their time in the building (Wolverton Environmental Services, 2020).

There is a need to embrace the principles of bioelectromagnetic design in the design of smarter lifetime homes. Very few architectural projects yet address the fact that both extremely low frequency magnetic fields and radiowaves are recognised as Group 2B carcinogens (IARC, 2002; WHO & IARC, 2011), and that raised electric fields created by either the frictional charging of materials or the use of poorly designed electrical equipment can increase local concentrations of harmful submicron contaminants in the air and the deposition of such contaminants onto individuals (Jamieson, 2019).

Many design firms and developers are also unaware that many insurance firms now refuse to cover the increasing risks related to electromagnetic pollution, leaving themselves potentially open to litigation.

CFC Underwriting LTD, an agent of Lloyd’s, have observed that *“The Electromagnetic Fields Exclusion (Exclusion 32) is a General Insurance Exclusion*

and is applied across the market as standard. The purpose of the exclusion is to exclude cover for illnesses caused by continuous long-term non-ionising radiation exposure i.e. through mobile phone usage.” As a result of this, special coverage is often required to address this issue (Environmental Health Trust, 2020). It has additionally been noted in the ‘Swiss Re SONAR: New emerging risk insights May 2019’ report by major international insurance firm the Swiss Reinsurance Company Ltd that “Current concerns regarding potential negative health effects from electromagnetic fields are likely to increase” (Swiss Re Institute, 2019).

Adopting ‘precautionary principle’ design and life-enhancing design.

There is much that can be done to improve this situation and enable healthier bioelectromagnetic environments to be created. As a simple (no cost) example of how this can be achieved, mention is made of the recommendations given by the Russian National Committee of Non-Ionising Radiation Protection (RNCNIRP) indicating how improved room layouts can be created to reduce local exposures to raised fields in the individual microenvironments within rooms. (Jamieson et al., 2010) (Figure 2.25)

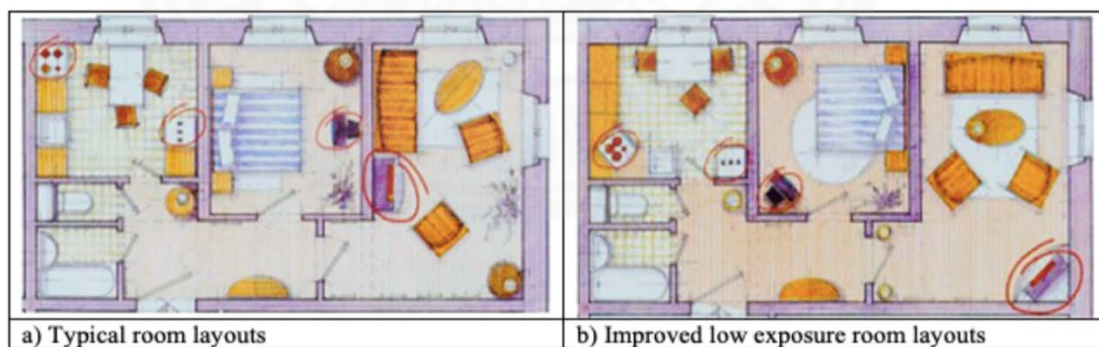


Figure 2.25 Example from the RNCNIRP on how to create low exposure room layouts
Source: Jamieson et al., (2010)

- **Electrostatic fields**

Furthermore, the presence of raised fields can greatly increase the local concentrations of charged submicron particles within individual microenvironments within individual rooms, indicating that the air quality within such areas is poorer than that found elsewhere in the same rooms. In the situation shown (Figure 2.26), the presence of high levels of electrostatic charge are indicative of higher local concentrations of charged submicron particles which have been shown to be harmful to health (Jamieson 2020a; Jamieson et al., 2010).

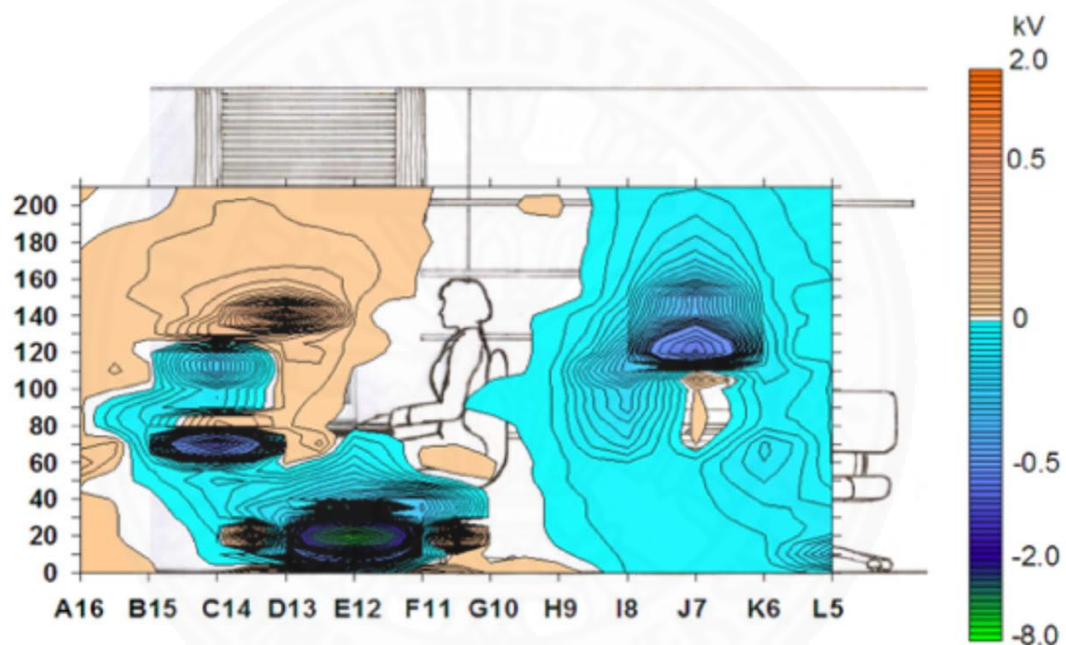


Figure 2.26 Electrostatic potential in computer area

Source: Jamieson et al., (2010)

- **Mains frequency electric fields**

It has also been indicated that mains frequency electric fields can influence air quality with regards to concentrations of charged submicron particles. For this reason, it is recommended that all electrical equipment should be earthed to help reduce the presence of excess charge in the microenvironments that individuals occupy when indoors. As a matter of best practice, it is suggested by Jamieson, (2020)

that all electric socket outlets installed in Thai buildings should be of the three-pin variety to help reduce the creation of raised electric fields.

- **Mains frequency magnetic fields**

In the typical room layouts shown in Figure 2.26, the fridge and microwave in the kitchen are located on the other side of the wall to the head of a bed, failing to take into account that the magnetic fields they create can easily pass through the wall. High magnetic fields are also created by the television in the bedroom that can pass through the wall to the occupants of the sofa in the living room. Additionally, in the living room under typical room layouts, there is an electric heater, that can emit high magnetic field fields located directly next to where someone may sit. The re-organisation of the room layouts, including the careful location of items of electrical equipment within them, helps reduce the likelihood of such exposures.

Examples of AC magnetic field strengths that can be commonly be found indoors are shown in Table 2.11 (Swiss Agency for the Environment, Forests and Landscape, 2005). That Agency also notes that there are a number of simple measures that can be taken to reduce individuals' exposures at home: "Switching off and unplugging appliances"; "Maintaining adequate distance from electrical appliances"; and "Avoiding the long-term use of electrical appliances close to the body."

Table 2.11 Magnetic field of Electrical appliances in the household Appliance

Electrical appliances in the household Appliance	Magnetic field (μT)		
	Distance of 3 centimetres	Distance of 30 centimetres	Distance of 1 metre
Hairdryer	6 – 2000	0.01–7	0.01 – 0.3
Electric shaver	15 – 1500	0.08–9	0.01 – 0.3
Drill	400 – 800	2–3.5	0.08 – 0.2
Electric saw	250 – 1000	1–25	0.01–1
Vacuum cleaner	200 – 800	2–20	0.1–2
Washing machine	0.08 – 50	0.15–3	0.01 – 0.15
Clothes dryer	0.3 – 8	0.1–2	0.02 – 0.1

Table 2.11 Magnetic field of Electrical appliances in the household Appliance (continue)

Clothes iron	8 – 30	0.1 – 0.3	0.01 – 0.03
Kitchen appliances Appliance	Magnetic field (μT)		
Electric cooker top	1-50	0.15-8	0.01-0.04
Microwave oven	40-200	4-8	0.25-0.6
Refrigerator	0.5-2	0.01-0.3	0.01-0.04
Coffee machine	1-10	0.1-0.2	0.01-0.02
Hand-held mixer	60-700	0.6-10	0.02-0.25
Toaster	7-20	0.06-1	0.01-0.02

Source: Swiss Agency for the Environment, Forests and Landscape, (2005)

Jamieson (2008) also mentions that individuals' exposures to AC magnetic fields within buildings should be "As Low As Reasonably Achievable" (ALARA), and that where possible exposure levels should be $\leq 0.1 \mu\text{T}$. He further suggested that, in addition to carefully zoning equipment to reduce individuals' exposures, electromagnetic field templates of individual electrical items should also be created and used as a design tool to help in the creation of low exposure zones and determine the choice of appropriate equipment to specify within a building.

- **Radio frequency radiation**

As noted by Jamieson (2020), despite radio frequency radiation already being classified as a Group 2B carcinogen, and the insurance industry stance on electromagnetic pollution and not generally covering design professionals against such risks (IARC, 2002; WHO & IARC, 2011; Environmental Health Trust, 2020), there is an increasing trend for manufacturers to make products and devices wireless. Amongst the numerous items that can now emit radio waves are the following: air conditioners; air purifiers; baby monitors; cameras; cordless phones; doorbells; fans; garage doors; headphones; humidifiers; lights; locks; outlets; receivers; routers; security; sensors; speakers; smart meters; sprinklers; switches; thermostats; toilets; televisions; and windows (Apple, 2020; Swiss Agency for the Environment, Forests and Landscape,

2005). All of these can emit electromagnetic pollution and add to the levels of electrosmog in the air around us.

As noted by the Swiss Agency for the Environment, Forests and Landscape (2005): “More and more wireless applications are now also being used indoors, ... Although their transmission power is often relatively low, these devices can dominate the indoor exposure to high-frequency radiation. To keep exposure as low as possible, these devices should be used at a due distance from places where people spend lengthy periods of time, including bedrooms, living rooms, home offices and children’s rooms.”

Smarter solutions do not need to create electrosmog that may damage individuals’ health and wellbeing. Potentially far healthier options such as Li-Fi (Bünger, 2016) are already here. Li-Fi (Light Fidelity) is a wireless communication technology like Wi-Fi but Li-Fi uses light to communicate instead of using radio waves, such as Wi-Fi technology, 802.11ac. Or 3G / 4G / 5G technology and has real test results in the office. Li-Fi can transfer data at a speed of 1 GB per second, which is 100 times faster than Wi-Fi. The opportunity exists to combine best practice smarter guidelines that directly seek to help enhance wellbeing for all and provide the conveniences of modern life (Technointrend.com, 2018).

Table 2.12 Proposed Precautionary Principle “Electromagnetic-Hygiene” Measures

Unipolar Air Ionisation	Prolonged exposure to standard unipolar SAI to be avoided	
Bipolar Ionisation	Balanced Ionisation regimes may be considered where practical	
Mandatory Minimum*	600 NSAI/cm ³	400 PSAI/cm ³
Optimal*	3,000 – 5,000 NSAI/cm ³	1,500 – 3,000 PSAI/cm ³
Mandatory Maximum*	50,000 NSAI/cm ³	50,000 PSAI/cm ³
Mandatory Minimum*	600 NSAI/cm ³	400 PSAI/cm ³
AC Electric Fields (1-2000Hz Range)		
Suggested Maximum	≤100 V/m [‡] , possible option for prolonged exposures	
Suggested Minimum	≤10 V/m	
Optimal	0 V/m, As Low As Reasonably Achievable (ALARA)	

Table 2.12 Proposed Precautionary Principle “Electromagnetic-Hygiene” Measures (continue)

Electrical equipment	≤ 10 V/m at 0.5m from source [†]
AC Body Voltage	
During sleep periods	≤ 0.01 volts
AC Magnetic Fields (1-2000Hz Range)	
Suggested Maximum [‡]	≤ 1.0 μ T
Suggested Minimum [‡]	≤ 0.2 μ T
Regularly occupied areas	≤ 0.1 μ T*, ALARA
DC Electric Fields	
Fields from Equipment	± 0.5 kV surface potential*
DC Electric Field strengths	
DC Electric Field strengths	20 kV/m, maximum adult exposures at 0.5m from source*
DC Electric Field strengths	15 kV/m, maximum exposures for children at 0.5m*
Humidity Levels	12°C dewpoint temperature (20°C at 60%RH to 24°C at 47%RH)
RF/MW Radiation	
Field levels indoors	ALARA

Source: Jamieson (2008), SanPiN (2003), TCO (1999), NCRP (1995).

2.6 Concepts and Theories about Studying the Development and Changes between Ages

2.6.1 Concepts and Theories about Child Development

2.6.1.1 Children from Birth to 1 Year Old (Infants)

Children in this age-range need time for physical adjustment to the new surroundings they find themselves in after leaving the mother's womb. To begin with they require lots of daytime naps, which decrease in frequency over the first year. Where possible the design of the home should enable a safe and stimulating

environment to be created that will help them obtain and refine the skills they need in five main areas: cognitive development; gross motor skill development; fine motor skill development; social and emotional development; and speech and language development (Sangprasert, 2013).

Areas should be baby-proofed as much as practical and designed so that visible and audible connections can be maintained between adults and infant as much as possible, even when the adult is not directly nearby, particularly as infants benefit from the psychological security of having a responsible adult within view when needed. Additionally, they should also be able to have visual contact with the outdoors at their own eye-level throughout this period. They should also be able to have access to the outdoors, when required, within a suitably protected play area that they can readily explore, again while under supervision from adults (U.S. General Services Administration, 2003).

2.6.1.2 Pre-School Children between 1-5 Years Old

This group has body that can adjust the body to the environment, with the body growing continuously began to be more mischievous because of doubts in the surrounding environment, causing children to have an accident unexpectedly in the household. (Sangprasert, 2013) Home is therefore an important tribute that helps promote learning of children of this age. Should also be safe and helps prevent accidents of children at this age.

2.6.1.3 School Age Children 6-12 Years Old

In this stage, the body of this group requires adjustment to the environment outside because the child started to go to the school has an outside society, which causes the risk of contracting diseases from each outside environment in different communities such as respiratory disease, fever, and hand foot mouth. (Sangprasert, 2013). Therefore, the environment that is important is that the accommodation must be clean, safe, quality air will help to encourage children at this age to be healthy.

2.6.2 Concepts and Theories about Adolescent Development

2.6.2.1 Group Age 13-19 Years Old

At this age, the transition between childhood and adulthood, there is a need for independence and acceptance in the peer group. Due to the rapid change of body and mind there can be intense emotions and confused mind, looking for their own. A house with a good atmosphere can help people in this age group to have their own space to relax and can relieve the stress (Sangprasert, 2013).

2.6.3 Concepts and Theories about Adult Development

2.6.3.1 Group Age 20-35 Years Old

By this age the body is fully grown. Health problems often encountered at this age are as a result of stress and lack of body care. At this age, emphasis should be given to physical and mental health promotion through participation of families and workplace organisation. Other than that, in the health issue should sleep well to reduce the cumulative risk factors that will cause the disease in the future (Sangprasert, 2013). Living in a good environment or living in a house that has a quality atmosphere and environment will help promote the health of people at this age to be strong and more productivity.

2.6.3.2 Group Age 35-59 Years Old

In this age individuals often work the hardest and have the most responsibility to the family. The problems often encountered with this are stress from mission in occupational which cause of many disease. The deep sleep is necessary to humans at all stages of life. During the period because the body is undergoing hormones to improve health. And breathing training; defining deep breaths and breathing long-lasting release by practicing can helps to reduce the stimulation of the nervous system and relax the overall effect in the long run which will good for physical and mental health (Sangprasert, 2013).

Reinforcing peoples need for connection with nature through creating gardening and urban agriculture initiatives can be particularly beneficial to the wellbeing of people within this age group. As an example, the University of Arkansas (2000) reports that females who are of fifty years of age or over, who garden at least

once a week, have greater bone density than those who do aerobics, jogging, swimming or walking. Additionally, the calories burnt through undertaking such activities are similar to those burnt during water aerobics, volleyball and yoga (Harvard Medical School 2014).

2.6.4 Concepts and Theories about Older People Development

2.6.4.1 Group Age 60 Years Old and above

It is in this age range that the deterioration of the body structure is greatest. The state of life throughout the state of mind, some are depressed, with not much sleep, lack of sleep, causing fatigue to the body. Not exercising which would otherwise allow the blood to pump and increase oxygen to the body more efficiently, and sometimes have the state of mind that can be stressful or negative, or often depressed. These are just some of the factors that can cause people's wellbeing to deteriorate (Sangprasert, 2013). So living in a good environment will help people to be able to be more active, sleep longer and improve their state of mind and general wellbeing.

2.7 Homes for the Future

'The way we live now: What people need and expect from their homes' is a special report prepared by Ipsos MORI on behalf of the Royal Institute of British Architects for the Future Homes Commission's investigation into how consumer needs and 21st-century housing should be designed to cater for people's needs (Finlay et al., 2012). Its in-depth insights, with regards to members of the UK public, were taken as a starting point with regards to investigating what may matter most in the future design of homes for those living within the Bangkok Metropolitan Region.

Its main findings, and comments on how smarter lifetime homes can help address these, are given below:

2.7.1 Emotional Considerations

That report noted that when people choose a home it is often emotional considerations that overrule practical ones. Now, through undertaking smarter design where wellbeing enhancement is taken into account, the emotional considerations can also become practical ones too. The wellbeing factor will become a major issue in the future and one that will help make the architectural projects that embrace it stand out above others.

2.7.2 Daylight Provision

It was revealed in the RIBA survey (Finlay et al., 2012) that the UK respondents wanted properties with large windows, high ceilings and lots of natural light. The benefits to health, productivity and wellbeing receiving biologically-beneficial exposures to daylight indoors, and how this can be achieved, is presently little known in Thailand.

There is a need to address many Thais' aversion to healthy light exposures through increasing the awareness of how to create more biologically-friendly designs and the benefits of doing so. Individuals also need to become better aware of the benefits of living in smarter lifetime homes that can perform this vital low-cost/no-cost enhancement to wellbeing through both intelligent system and by design means.

There are a number of the ways that healthier light exposures can be created indoors, even in this country. Architects and engineers need to be aware of how more appropriate exposures to good quality natural light can be created indoors without individuals suffering from glare or homes becoming very hot. They should also be prepared to educate others on this important issue. Smarter lifetime homes can be designed to help ensure that dwelling occupants receive biologically-optimised exposures to light.

2.7.3 Design Layouts

When seeking to optimise design layouts for end-users, designers also have to take into account that different design solutions may be required at different stages of a person's life journey, and also transient short-term changes that may be required or seen as worthwhile (Finlay et al., 2012). Homes should be designed using the Lifetime Homes approaches so that changes in user needs can be easily addressed through minor changes in the initial design – plan variants should be shown indicating how a home can be adapted for all life stages. Generally, the respondents to the UK survey stated that they preferred some degree of open planning to make the designs flexible enough to entertain friends and family when needed.

It is therefore proposed that for smarter homes, as is the case with the Lifetime Homes approach, the core design for units should be flexible enough to adapt to both short-term and long-term changes with minimum reorganisation. It is also proposed that, as an option, when homes are sold – particularly those for large-scale developments – illustrations of a variety of bio-friendly and life-stage friendly variations of schemes can be provided demonstrating how the dwelling can easily adapt through time to occupants changing needs.

A variety of flexible design solutions can be proposed to help achieve design flexibility (Finlay et al., 2012), such as movable partition walls or screens, window openings that can be easily changes into door openings (and vice versa), the provision of extra plumbing and electrics connections – or space for these - at time of construction. Such initiatives can make later modifications easy and at far lower cost and disruption than would otherwise be achievable.

It is proposed as part of the progressive smarter design approach suggested in this thesis that time be spent considering how to best optimise the use of space for the needs of distinct end-users. As examples the needs of the following: individuals working at home; individuals relaxing at home (both by themselves and with others); children playing and interacting with others at home; teenagers and their friends; predominantly sedentary people (such as many older individuals towards the end of their lives); and active individuals could all be assessed as part of this approach

and flexible designs to meet their needs fine-tuned accordingly. Their progressive and changing needs should also be factored in.

2.7.4 Privacy Needs

It was revealed by participants in the research undertaken for the RIBA report that they considered that it was very important that they had space which enabled them to spend time alone away from others in the dwelling. Participants of all ages considered that this provision was very important to their wellbeing. The need for this was particularly apparent for homes where multi-generations lived together, and also in situations where a member of the dwelling was convalescing or ill (Finlay et al., 2012).

It is proposed that minor modifications could be undertaken with relative ease to standard building plans to allow privacy needs to be better met and quality of life enhanced. As example of this, is the proposed creation of easily accessible extra garden space over carport roofs (Figure 2.28).



Figure 2.28 Reconfiguration of standard building designs can provide extra garden space to help address privacy needs (and create further health and wellbeing benefits)

Source: Kamolchaiwanich, (2020)

2.7.5 Electronics and Technology Use

The respondents in the RIBA report (Finlay et al., 2012) said they thought the design layouts for new homes should better consider the types of technologies likely to be used within them, and also how these could be stored when not in use. The idea of improving design layouts, and the consideration of what technologies are likely to be used, can be developed further by applying the principles of smarter biologically-friendly lifetime homes design.

Due to the concerns mentioned earlier in this review related to the impacts that electromagnetic pollution may have on health (IARC, 2002; IARC & WHO, 2011; BioInitiative Working Group, 2012; Environmental Health Trust, 2020), it is proposed that best practice bioelectromagnetic design initiatives be undertaken when considering layout designs and the types of electronic devices used by individuals (and how they can be used) in order to enhance electromagnetic hygiene. As mentioned earlier, one way to help achieve this is through the proficient use of EMF design templates to bio-electromagnetically optimise room layouts (Jamieson, 2008).

It is furthermore proposed that provision should be made for people to be able to easily use wired devices with fiberoptic connections rather than wireless technologies within rooms to reduce their electromagnetic field exposures. Investigation should additionally be made into the appropriateness of using Li-Fi and infrared connections for those who wish wireless connectivity. Adequate provision of low EMF hard-wired connections for corded phones should additionally be considered at design stage to help individuals lower their exposures.

It is additionally suggested that the need for digital privacy should also be taken into consideration in the design of smarter lifetime homes. This includes addressing the need for privacy from devices that can record sound and video of what occupants are saying and doing.

2.7.6 Socket Outlet Provision

Finlay et al., (2012) mentioned in the RIBA report that there is a need to have adequate provision of electric sockets within homes, with participants in that review mentioning that they expected dwellings to have enough sockets to allow for a variety of room layouts and device locations. With regards to this issue, it is worth noting that there are often too few sockets provided in Thai homes, particularly in kitchen areas, and that a strong case can be made for the inclusion of demand switches in bedrooms to fully disconnect electrics in those rooms and reduce individuals' exposures to electromagnetic fields when they sleep (Jamieson, I.A. (2020), personal discussion with author).

2.7.7 Storage Provision

Participants in the survey work undertaken for the RIBA recognised, after prompting, that most new-build properties have far too little storage provision. In particular, they thought there should be far more long-term storage (for treasured possessions and seasonal items) and more short-term storage (often for foodstuffs and clothing). Additionally, many of the participants stated that it was difficult to find dedicated space in new-build properties for items such as: clothes horses, ironing boards, vacuum cleaners, rubbish bins and recycling bins. The actual location of storage areas within a dwelling was also a point of concern, with many participants having stored items that they accessed regularly that they wished to keep private from visitors. They also raised the point that having nearby communally accessible areas outdoors for particular types of rubbish and reuse/recycling activities would be desirable (Finlay et al., 2012).

Storage needs are seldom adequately thought of in the design of Thai many homes. Measures such as having double-height cupboards (that reach to the ceiling) in kitchen and having storage space easily accessible within roof space would in smarter design initiatives would in part help address this. The provision of extra-wide corridors in smarter design initiatives, as advocated within the Lifetime Homes approach, would also mean that properties could become more flexible to changing needs and in many cases be able to provide extra storage.

2.7.8 Temperature and Noise Issues

A strong business case could be developed for best practice design measures that reduce indoor heat loads and increase acoustic privacy. Many individuals report problems related to these factors in the properties they buy (Finlay et al., 2012). The benefits of improved levels of thermal insulation are seldom considered at time of buying unless individuals are prompted to do so. A strong financial case can be made related to the energy savings achievable through properly insulating buildings.

Though acoustic privacy is important to individuals, potential noise issues, or the benefits to wellbeing of living and working in better acoustically-insulated properties, are seldom considered by prospective purchasers unless they are prompted to do so. Domestic buildings, their surroundings, and in particular the rooms in which individuals sleep, can be better designed to help provide improved levels of sound insulation to better protect occupants from noise pollution from external sources. A strong case can also be made for how reduction of exposure to noise pollution can benefit wellbeing. Added insulation can address both the temperature and acoustic issues that many dwelling occupants would otherwise have.

2.7.9 Rating Buildings on How They Can Contribute to Wellbeing

Individuals who participated in the RIBA survey into future homes thought it was a good idea to provide ratings scores on how buildings compared with each other on important aspects (Finlay et al., 2012). That work also suggests that: “An independent, cross-professional body should regulate the quality of, and provide free information about new-build homes” and that “Free information should be available to benchmark aspects of quality such as space, noise insulation and energy efficiency.”

It is proposed that such ideas can be developed even further to help develop smarter lifetime homes that enhance wellbeing for all generations. It is therefore suggested that this present work, and its findings, be taken as a blueprint to develop just such an independent, cross-professional body initiative in Thailand. However, it would take things even further than proposed in the UK and have wellbeing at its core.

This type of scoring method appears particularly valuable on raising awareness on important health and wellbeing related issues that many individuals would not initially consider when wishing to purchase, or renovate, a property. It is proposed that a ratings scheme should be developed to show how the design of individual buildings can contribute to wellbeing.

2.8 Conclusion of Literature Review

Conclusion from the above literature review, it has been demonstrated from the research materials discussed in this chapter that there are a number of physical environmental design factors that can be better refined to enable people in all groups, ages, and generations to be healthier and live longer. Wellbeing can be further enhanced through the proper design and management of the physical environment. It is possible to develop smarter lifetime homes that enhance wellbeing for all generations through seeking ways to better enhance biological wellbeing and aid functioning at all stages of life. It is further proposed that doing so will create new markets and layers of sustainable innovation and increase wellbeing for all.

CHAPTER 3

RESEARCH METHODOLOGY

The methodology adopted for this thesis ‘Developing Smarter Lifetime Homes That Enhance Wellbeing For All Generations’ combines a comprehensive multi-disciplinary review with qualitative research investigating the opinions of industry experts and stakeholders to critically review and assess the current situations that exist with regards to the design and refurbishment of domestic properties within Thailand.

It also suggests a blueprint for how ‘smarter lifetime homes’ that enhance wellbeing for all generations could be cost-effectively created as the new standard.

3.1 Research Location

The literature review investigated international best practice and scientific findings from related specialisms to help determine what may be required to create smarter lifetime homes with regards to the context of Thailand real estate development and refurbishment of existing properties, with particular emphasis being given to the Bangkok Metropolitan area.

3.2 Key Informant

The key informants used in this study are a group of eight design professionals with expertise in health and wellbeing building design from the Research Innovation Sustainability Center (RISC) and the professionals from the Faculty of Architecture and Planning at Thammasat University. Members of the general public additionally acted as stakeholders representing five key types of homeowner.

3.3 Research Tools

In conducting the research, the researcher has determined the research tools required according to the following objectives:

- 1) To review how the design of dwellings, and the technologies and materials used within them, impact user satisfaction and wellbeing.
- 2) To look at current best practice initiatives with regards to the creation of lifetime homes, and inclusive design measures.
- 3) To consider additional design factors that scientific research indicates can enhance both short and long-term physical and psychological wellbeing.

The researcher has specified the research tools required to undertake the following:

- 1) Secondary research through literature review including documents, texts, articles, case studies, scientific research and research from related fields compiled from government agencies and private sectors both inside and outside the operation area.
- 2) Primary research from questionnaire survey and collection of data on design characteristics of dwellings.
- 3) Undertake in-depth interviews with those professionals to further integrate their feedback and comments with findings made from the critical literature review to create an initial draft of the blueprint for best practice guidelines on 'Developing Smarter Lifetime Homes that enhance wellbeing for all generations'. This will then be refined as a final draft of the blueprint for best practice guidelines on this topic.
- 4) Using questionnaires to evaluate the blueprint for the guidelines which will be evaluated by the ten design professionals with expertise in health and wellbeing building design.

3.4 Research Period

The study period allocated to this research is 40 weeks (August 2019 - May 2020).

3.5 Research Plan and Methodology

The study's research methodologies are as follows:

Study existing standard practice as related to the design of dwellings in the Bangkok Metropolitan Area.

1) Study existing best practice for lifetime homes guidelines and general standard home designs, plus relevant findings from related fields as related to how to increase wellbeing through better design of the areas people live in.

Study secondary data. The literature review includes critical review of relevant documents, texts, articles, case studies, scientific research and research compiled from government agencies and private sectors both inside and outside the operation area as related to how improved wellbeing may be achieved through undertaking better informed design decisions.

2) Create check-list form then review, survey and collect data on design characteristics of dwellings.

After conducting literature review then create a check list, undertake the questionnaire survey and then collect further data as required as related to the design characteristics of dwellings.

3) Interview relevant experts and members of the public.

- Interview relevant experts

Select a group of eight design professionals with expertise in health and wellbeing building design from the Research Innovation Sustainability Center (RISC) and the professionals from the Faculty of Architecture and Planning Thammasat University. Undertake in-depth interviews with those professionals.

- Interview relevant members of the public

Select five key types of homeowner: Single person; Couple without children; Couple with child/children; Single parent with child/children; Older couple. Undertake interviews with them to gain their feedback.

- Integrate findings from interviews into research plan

Integrate the feedback and comments received from all interviewees with findings made from the critical literature review to create an initial draft of the blueprint for best practice guidelines on ‘Developing Smarter Lifetime Homes that enhance wellbeing for all generations’. This will then be refined as the final draft of the blueprint for best practice guidelines on this topic.

4) Conduct further reviews, as necessary, of case-studies, scientific research and best practice that indicate how the problems identified can be solved. This task work includes taking on board the ideas and feedback generated by the design professionals and the feedback obtained from the representative stakeholders.

5) Create blueprint for proposed best practice guidelines for assessment by the original ten design professionals via further questionnaire and interviews.

Create blueprint for proposed practice guidelines. Use questionnaires for the original ten design experts to evaluate the blueprint of the guidelines. This stage is incorporated in order to address any errors and to pinpoint any specific recommendations that should be developed further for the blueprint for the best practice guidelines.

6) Review feedback and then refine the blueprint of the proposed best practice guidelines.

Evaluate the feedback given to improve, refine and finalise the blueprint for the best practice guidelines on ‘Developing Smarter Lifetime Homes That Enhance Wellbeing For All Generations’.

3.6 Research Schedule

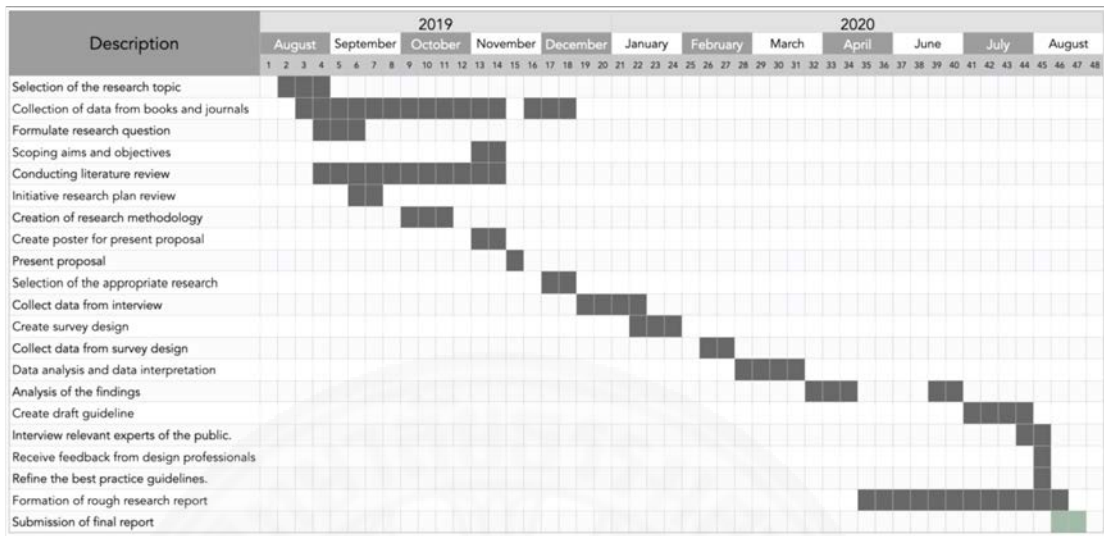


Figure 3.1 Research Schedule

Source: Kamolchaiwanich, (2020)



CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter discusses the data analysis and findings from questionnaire completed by design professionals with expertise in health and wellbeing building design and members of the general public acting as stakeholders. The purpose of this study was to investigate how to develop smarter lifetime homes that enhance wellbeing for all generations. Suitable to be brought these guidelines and the insights generated from this work can be used by those in industry wishing to create more bio-friendly next generation products, and by individuals wishing to enhance the health and wellbeing of both themselves and their loved ones to create wellbeing for all.

4.1 Data Collection

This in-depth interview is divided into two groups, with the researcher choosing to study the key informants of both groups that are important. And is relevant to the research by using the purposive sampling method and collecting data from in-depth interviewing. The key informants are divided into two groups, the first group is comprised of 8 design professionals with expertise in health and wellbeing building design, the second group is comprised of 14 members of the general public acting as stakeholders within that and is comprised of relevant members of the public that are taken from the following demographic groups: Single person; Couple without children; Couple with child/ children; Single parent with child / children; Older couple.

4.1.1 Design Professionals with Expertise in Health and Wellbeing Building Design

- 1) Assist.Prof. Chorpech Panraluk
- 2) Supmanee Chaisansuk
- 3) Sarigga Pongsuwan Ph.D.
- 4) Saritorn Amornjaruchit

- 5) Vasuta Chan
- 6) Napol Kieatkongmanee
- 7) Panpisu Julpanwattana
- 8) Chanin Kulsurakit

4.1.2 Members of the General Public Acting As Stakeholders

- 1) Single person (3)
- 2) Couple without children (2)
- 3) Couple with child/ children (3)
- 4) Single parent with child/ children (2)
- 5) Older couple (4)

4.2 Questionnaire and Interview

Interview session for design professionals with expertise in health and wellbeing building design and members in general public: The investigation of related factors leading to the development of smarter lifetime homes that enhance wellbeing for all generations in Thailand.

4.2.1 Qualitative Research Analysis

In this research, qualitative research was conducted by in-depth interview. from the design professionals with expertise in health and wellbeing building design and members of the general public acting as stakeholders. The researcher is informed of how to develop smarter lifetime homes that enhance wellbeing for all generations as well as other work related to house development and improvement based on the experience of members of the general public. Analyzing the data obtained from interviews use analysis with data classification methods, data comparison and creating inductive summaries.

Procedures

This interview is comprised of 4 sections:

- 1) General Information of key informants
- 2) Background and main research questions; The feedback that key informants give to the main research questions will help reveal what the building industry can do to address this matter and help enhance wellbeing for all.
- 3) Open-ended questions; The questions key informants are asked enables them to give their opinions freely as specified in the questions. This can resulting in profound information being provided that reflect their true feelings. From the questionnaire, open-ended questions were asked based on what participants experienced in their own lives, the houses that they lived in, and things that they found need to be improved.
- 4) Level of agreement; Agreement level in order to assess the opinion regarding the quality and the environment in the housing.

4.3 Results

4.3.1 Results from Interview and Questionnaire Design Professionals with Expertise in Health and Wellbeing Building Design

4.3.1.1 Part 1

General information of interviewees from an interview with 8 design professionals with expertise in health and wellbeing building design.

General information of interviewees from an interview with 8 design professionals with expertise in health and wellbeing building design. This group was comprised of 3 males and 5 females.

Most of them are in Millennials or Generation Y: Born 1981-1996 (24 -39 years old) at 62.5%, follow by Generation X: Born 1965-1980 (40-55 years old) at 37.5%.

Six of the design professionals are single and two are married.

With regard to their education levels, six have a Master's degree and two have Doctor of Philosophy degrees.

Seven of them live in Bangkok and one lives in a provincial area.

Three of them live in detached houses, two live in townhouses, one lives in a twin-house, one lives in a commercial building, and one lives in a condominium. Only one of them has children, and that person has their children living with them. Six of them live with their parents and two do not.

4.3.1.2 Part 2

From the main research question about How can we develop smarter lifetime homes that enhance wellbeing for all generations? According to the interview of design professionals with expertise in health and wellbeing building design. The researchers can conclude that they can be develop as follows:

1) The design of the dwelling must consider the usage of the occupants of the house. The functions of a dwelling that is flexible enough to easily enable changes as occupants' circumstances change are conformed to the interview as follows:

“Lifetime home must relate to every group of people living in the home including activity in and using the space in the house differently.” “The important thing is that there is still private space in the area that still interacts with the people in the house.”

(Design professional, key informant 3)

“The house has functions that can be adjusted according to usage...to response all activities of the occupants in the house.” “And meet the needs of all ages regardless of how long the time has passed but the house can always support the use.”

(Design professional, key informant 5)

2) Another issue that needs to be developed is indoor air quality (IAQ), which should be considered very much. The problems that informants in the expert group are very common in their home are the matters of ventilation, lighting to receive natural daylight that is appropriate for work, to receive good quality air, proper ventilation, the appropriate temperature and humidity are conformed to the interview as follows:

“The design factors that can improve the quality of life of the occupants are the function design, material selection, various elements that help reduce accidents and increase healthy. Active living, IAQ that reduces the accumulation of mold in the house and can reduce allergy. The location of the air conditioner also affects the health and also the plug.”

(Design professional, key informant 3)

“The designs that do not have ventilation will cause bad indoor air quality. There will be stuff that doesn't drain moisture. Therefore causing mould designed to be difficult to clean and contain dust, it will create a dust container in the house...However, the addition of a limited space may lead to the addition of limitations, such as not receiving natural light so having a confined space.”

(Design professional, key informant 4)

3) From the second main research question about How does the design of dwellings, and the technologies and materials used within them, impact user satisfaction and wellbeing, and how can a smarter approach help enhance lifelong wellbeing all stages of life? According to the interview of design professionals with expertise in health and wellbeing building design. The researchers can conclude that they can develop as follows:

All three issues affect the satisfaction of users and affect the well-being. It can also improve the quality of life as well. Start with good design dwelling. Placing the structure in the right direction that receives natural light but not being exposed to excessive heat from the sun will help save energy. Able to receive natural light and does not need to use materials or insulation. It is economical in construction. And good design dwelling will affect long-term use. The occupants do not need frequent repairs or maintenance. That greatly affects the satisfaction of occupants. Aside from the above, the design dwelling can also improve the quality of life for safety and supports all ages. which are conformed to the interview as follows:

“Everything that has been said is related to each other. Good designs must be built with good materials. In order to pass on to the residents to have a good living experience. If the house is designed beautifully but poorly designed building materials such as light walls, leaky roofs, incorrect lights, lighting, and eye strain. Everything will have the same effect and the key person that will affect the construction or design is very important. Which requires awareness among the workers involved let these issues have a greater impact, not just about beauty. But it's about the quality of living.”

(Design professional, key informant 8)

“How to place the direction of the house, north, light all day little heat and the direction that makes people wake up or perceive the most light slept in the direction that was perceived by the time of day. The Eastern light can affect the circadian rhythm in his life.”

(Design professional, key informant 3)

“More security and safety should be designed from the beginning...The function layout, the stationary zone layout that responds to the comfortable conditions.”

(Design professional, key informant 4)

4) The second issue is the materials used in construction. It can be concluded that it affects the satisfaction and can improve the quality of life of users. Due to various construction materials If the material is of poor quality, it will cause problems while using that resulting in constant maintenance and costly waste. Some materials emit volatile substances that are harmful to health, both short-term and long-term. Therefore, smart home development that enhance wellbeing all stages of life is necessary to start from the materials of designing to build a good quality house. Not harmful to the body and use. In addition to health. The selection of materials also affects the home which helps to save more energy which are conformed to the interview as follows:

“It affects to safety and health, such as how to choose materials that are safe for health (no toxic or VOC), non-hazardous materials such as non-slip tiles. Designed to be safe to the standards.”

(Design professional, key informant 4)

“Selecting good materials will be a matter of choosing quality materials. Do not need frequent repairs, choosing materials that are safe to use, for example, should not choose materials that are exposed to water and the floor is often slippery, choosing materials that can prevent heat well, tile floors. Tile floors keep excess cold. When our feet are touching, it may make us more unwell.”

(Design professional, key informant 6)

“The material is very important such as a tile floor for the elderly. We can see that the area suitable for the elderly is a wooden floor. Or tiles with suitable anti-slip values. So it is not slippery when it wet and this tile area is usually not used in the area that the elderly use regularly such as the bedroom because there is a lot of cold transfer. It will make the elderly step on the ground and then will be cold.”

(Design professional, key informant 2)

5) The next point is the use of technology to promote. Makes it possible to live with more comfortably. Technology affect the satisfaction of users and can improve the quality of life better. The use of technology involved design of dwelling at first. Due to the good design of dwelling, the use of technology can better meet the needs and allows people to live life easier. Some technologies can help with safety issues. which are conformed to the interview as follows:

“Good design directly affects the use of good technology. If there are additional facilities Making it able to respond to our needs well will enable us to live life easier.”

(Design professional, key informant 6)

“Technology such as smart watch devices worn for the elderly in case of accidents or sensor movement in the situation that there is a serious accident or abnormal movement. It can be sent to the smart watch in order to let members in the house know and able to help in time.”

(Design professional, key informant 2)

4.3.1.3 Part 3

Open questions; Asking based on what participants experienced in their own lives. That they live in the house and found that things need to be improved.

1) Homes are important to experts divided into many perspectives. Both in the matter of the house as a place to rest for physical and mental. The home is important in term of a place where activities can be shared with family members. Which can be linked to relationships within the family. The importance of a home does not mean a large or beautiful home. But the home is important in designing for proper function and supporting physical usage and has mental importance warmth matters in the family which are conformed to the interview as follows:

“Where the family members live It is an area that supports us. In our routine, the house must be a place where we can relax. The house is a way of family members. Home is the place to do activities of various people. Home is a place that allows our members to be together. Have joint activities.”

(Design professional, key informant 8)

“Looking into a warm family with love and harmony. The house is not just a house, both mental and physical. There can be interpreted in many dimensions in terms of design.”

(Design professional, key informant 1)

“Relationships within the family. Peace, if the family has peace, warmth. A beautiful house may not be necessary for us much.”

(Design professional, key informant 7)

2) Another topic that are a lot of problem that happen in the house among experts. The researcher found that the current house that lives have not good indoor environment quality. The house does not have a good ventilation system. Resulting in damp, dust and pollutants that can enter the house can cause discomfort in the home. One expert lives in a commercial building, which limits the exposure of natural light. In addition to the environmental quality inside the building. There is a matter of designing buildings that are not support for use in all ages. Most problems are caused by having an older person in the house who may be more prone to having an accident. Accident caused by materials used in the construction. Various tiles do not have anti-slip values therefore it is one of the causes of accidents for the elderly which are conformed to the interview as follows:

“Light is the most common problem because of my resident is commercial building so the natural daylight can reach from in front of my building (one way)”

(Design professional, key informant 4)

“The function is not good as the house has been living since childhood that combined function...The direction of house is not good, the light is not good, the house is dark, the wind is not through, the ventilation is not good, the step is not good.”

(Design professional, key informant 3)

“The wind does not flow. The sun is very hot. Incorrect direction of house, various shading is not appropriate... As for the quality of air quality in the home, there are a lot of things. The management is not good, causing the unmanaged things to cause blind spots that will cause foul smell. I want to improve this area to have more light for better ventilation.”

(Design professional, key informant 8)

“Slippery bathroom tiles If not using granite, it may cause slippery or it may be that the tiles are corroded from use and therefore may be slippery in the bathroom.”

(Design professional, key informant 7)

3) Therefore, the problem should be addressed. Beginning with the planning design of dwelling with regard to users or members of the household and their health and wellbeing. The dwelling should be designed to support ease of use for all ages and stages of life and be as biologically friendly as practical. It should optimise the environment within the building, and also where possible its surroundings, to help promote and improve the general health, wellbeing and quality of life of its occupants. This includes addressing air pollution, ensuring that the quality of light provided in the dwelling is suitable for various activities, that there is suitable temperature and humidity that can be controlled, and good connections are provided with nature. Other than that, the use of construction materials is also a matter of consideration with regard to the health and safety and also long-term user-satisfaction. These factors need to be taken into consideration for every period of use of the house, with their need being are confirmed from interview as follows:

“Various environments are conducive to relaxation. In aspects of IEQ in terms of thermal comfort such as temperature, humidity, wind speed, metabolic values of the body. Good design helps promote good conditions for us, such as deep sleep. Depends on the amount of carbon dioxide.”

(Design professional, key informant 2)

“The design factors that can improve the quality of life of the occupants, how can we help us to live in harmony with nature and the environment? May help in many subsequent issues such as allocation of various building designs, for example, if we design in terms of reducing the heat that can enter the building. We may not have to add more things to add appliances in the house to prevent or reduce the heat in the house again.”

(Design professional, key informant 1)

“The design factors that can improve the quality of life of the occupants are the function design, material selection, various elements that help reduce accidents and increase healthy. Active living, IAQ that reduces the accumulation of mold in the house and can reduce allergy. The location of the air conditioner also affects the health and also the plug.”

(Design professional, key informant 3)

“Appropriate function design and can be adjusted in the future; Factors in terms of comfort, such as proper humidity and temperature, heat protection, good ventilation, suitable natural daylight.”

(Design professional, key informant 6)

4.3.1.4 Part 4

Agreement level in order to assess the opinion regarding the quality and the environment in the housing.

The level of opinion interpretation is as follows:

- 1) Average 4.51-5.00 means Strongly agree
- 2) Average 3.51-4.50 means Agree
- 3) Average 2.51-3.50 means Neutral
- 4) Average 1.51-2.50 means Disagree

5) Average 1.00-1.50 means Strongly disagree

The result of evaluating the level of approval of design professionals with expertise in health and wellbeing building design on the level of agreement of environmental impacts in the building. Found that the level of agreement with a total average of 4.38

Table 4.1 Average of agreement level of design professionals with expertise in health and wellbeing building design

Agreement level in order to assess the environment in the housing.	Design professionals	
	Average	Agreements Level
Having good quality air to breathe increases both short-term and long-term wellbeing.	5.00	Strongly agree
Having increased contact with nature increases wellbeing.	4.75	Strongly agree
Smarter designs of homes can help address many of the challenges we face from climate change.	4.13	Agree
The initial design of a dwelling should be flexible enough to easily enable changes to be made to it as occupants' circumstances change.	4.88	Strongly agree
As mains frequency magnetic fields and radiowaves are Group 2B carcinogens (and many insurance policies do not provide cover for them), design measures should be taken to help reduce occupants' exposures to these.	4.75	Strongly agree
Indoor environments should be designed to help improve people's fertility levels.	4.38	Agree
Biologically improved buildings can help improve both long-term and short-term health.	4.88	Strongly agree
Receiving good levels of daylight, including occasional sunlight, when indoors is important.	4.63	Strongly agree
I have enough personal privacy when I need it in my home.	3.75	Agree

Table 4.1 Average of agreement level of design professionals with expertise in health and wellbeing building design (continue)

There is usually enough storage space in new homes.	3.50	Agree
There is enough space for easy storage of clothes horses, ironing boards, vacuum cleaners, rubbish bins and recycling bins in my home.	3.25	Neutral
It is important to design homes in ways that can increase the wellbeing of occupants.	4.88	Strongly agree
Having design guidelines on how to increase occupant wellbeing is important.	4.75	Strongly agree
It is important for buildings to be designed in ways that enable people to live healthier, happier more productive lives.	5.00	Strongly agree
More designers should be made aware on the effect of the design of the environment on wellbeing.	5.00	Strongly agree
Ratings on how good individual buildings are at contributing to user-wellbeing should be created and made easily available.	4.63	Strongly agree
Smarter bio-friendly lifetime homes should be created as standard within Thailand.	4.38	Agree
The dwelling should have extra insulation to help reduce their energy use and keep people cool.	4.25	Agree
People would pay for extra insulation if they knew how much it could save them.	3.75	Agree
Exposure to even low levels of light at night is linked with increased risks of cancer, obesity and depression. You think smarter design measures should be introduced to reduce such risk.	4.25	Agree
You are often disturbed by noise both within and outside your home.	3.38	Neutral

Table 4.1 Average of agreement level of design professionals with expertise in health and wellbeing building design (continue)

You consider sound insulation that important to improving the quality of your home.	4.00	Agree
There should be nearby communally accessible areas outdoors for particular types of rubbish and reuse/recycling activities to help reduce waste.	4.50	Strongly agree

A strongly level of agreement was found between the design experts for the following: that more designers should know how the design of the environment can impact wellbeing (5.00); designing buildings to enable people to live happier, healthier, more productive lives is important (5.00); good air quality is important (5.00); there is a need to create biologically-friendly buildings to help improve occupant health (4.88); it is important to design homes appropriately so they can help increase wellbeing (4.88); designs should be flexible enough to deal with users' changing needs (4.88); increased contact with nature is beneficial to wellbeing (4.75); the need for design guidelines on how to reduce occupant exposures to electromagnetic pollution (4.75); it is important to have guidelines on how occupant wellbeing can be improved by better design (4.75); it is important to provide suitable exposures to sunlight and daylight (4.63); a rating system should be developed to indicate how good individual buildings are at contributing to the wellbeing of users (4.63); Have nearby communally accessible outdoor areas for rubbish and recycling/reuse activities to help reduce waste (4.50).

Furthermore, they exhibited an average level of agreement that showed that they additionally agreed on the following statements: smarter bio-friendly lifetime homes should be created as standard (4.38); indoor environments should be designed to help improve people's fertility levels (4.38); homes should have extra insulation to help reduce energy expenditure and keep people cool (4.25); as exposure to even low levels of light at night is linked with increased health risks, design measures should be introduced to address this (4.25); smarter designs of homes can

help address many challenges resultant from climate change (4.13); sound insulation important for improving the quality of a home (4.00); people would pay for extra insulation if they knew how much it could save them (3.75); I have enough personal privacy when I need it in my home (3.75); there is usually enough storage space in new homes (3.50).

Summary

The evaluation of experts with the level of agreement with the quality of the indoor environment that affects the well-being at the agreeing level $\bar{X} = 4.38$

4.3.2 Results and Conclusion from Interview and Questionnaire

Members of the General Public Acting as Stakeholders

4.3.2.1 Part 1

General information about the 14 members of the general public, 6 males and 8 females, that were interviewed and acted as stakeholders representing the following demographic groups: Single person; Couple without children; Couple with child / children; Single parent with child / children; and Older couple.

General information of interviewees from an interview with 14 members of the general public acting as stakeholders, found that 6 males and 8 females.

Most of the participants are in Millennials or Generation Y: Born 1981-1996 (24-39 years old) (7 persons); followed by Generation X: Born 1965-1980 (40-55 years old) (3 persons); and Baby Boomers: Born 1946-1964 (56-74 years old) (4 persons).

9 of the respondents are married: 4 are single; and 1 preferred not to answer. With regard to their education: 7 have Bachelor's degrees; 5 have Master's degrees; and 2 had received education up to Primary School level.

They have monthly incomes ranging from around 15,000 Baht to over 60,000 Baht. 6 of them have monthly incomes of more than 60,001 Baht; 4

have incomes of 40,001-50,000 Baht; 1 has an income of 15,001-20,000 Baht; and 3 has an income of between 20,001-30,000 Baht.

All of the participants live in Bangkok. Most of them live in detached houses (9 persons), with each of the remaining 5 individuals living in different types of housing, specifically: twin-house (2); townhouse (1); commercial building (1); and condominium (1). 9 of the respondents have children, and of these 9 there were 8 individuals who had their children living with them. The rest were without offspring. Additionally, 10 of the 14 live with their parents and 4 persons do not.

4.3.2.2 Part 2

From the main research question about “How can we develop smarter lifetime homes that enhance wellbeing for all generations?” According to the interview of members of the general public acting as stakeholders, the researcher can conclude that they should be developed as follows:

In order to be able to develop a house that is suitable for all ages, the needs of people in the home need to be addressed for all stages in their life journey. Starting by planning the structure of house so that different parts of the house can support the usage and safe for users. Also take into account factors such as exposures to natural and artificial light at different times of the day and how these can be optimised. Construction materials and design layouts need to respond well to the needs of the occupants. Various furniture configurations can be designed or specified to support their body at all ages. Also bring appropriate technology into the dwelling to help the occupants live safely as well as helping with convenience as documented in the interviews that follows:

“Plan first about members of family and think about what are their ages. So plan the area that can be adjusted according to use, convenient, safe.”

(Couple without children, key informant 3)

“Study first what the structure should be like at first and set the function. Then adjusted according to the plan according to the usage plan throughout

life.”

(Single, key informant 7)

“Must have facilities such as electrical system that will have sensors, security system that helps to alert if have something wrong.”

(Older couple, key informant 11)

“Use technology to help. Furniture must be adjusted that able to support our body.”

(Single, key informant 8)

From the second main research question about “How does the design of dwellings, and the technologies and materials used within them, impact user satisfaction and wellbeing, and how can a smarter approach help enhance lifelong wellbeing all stages of life?”; the feedback from the members of the general public acting as stakeholders was as follows:

“Affects because of the materials and equipment. If they are good, then do not need to buy to change them often. If we make the floor of a non-slip material, we do not need to be afraid of slipping falls. The bathroom can be renovated with extra accessories or the bedroom has space to make a handrail. The electrical system for lifting up and down the elderly should be easily controlled. Easy to access, near, convenient, may be by remote control.”

(Single, key informant 8)

“The first factor is the design of dwelling is the most important thing. The next factor is the materials used because high quality of material can affect the health of occupants. The last factor is about the technology used to increase convenience.”

(Couple without children, key informant 3)

“Definitely a house with technology. Convenient to use resulting in a well-being.”

(Single, key informant 7)

“It can cause an affect because it is an important issue in living in the house. I think the most important factor is technology, such as sensor systems that can help me to live with convenience.”

(Older couple, key informant 11)

“It can impact user satisfaction because good quality material can be important. If construction material is high quality, it is durable and we can use it for a long time. No need to repair, renovate or bring the technology to help.”

(Couple with children, key informant 9)

“Depending on the demand of each members. No matter the excellence of the design if nobody uses it, it is useless. Technology and materials have to be useable and of reasonable cost.”

(Couple with children, key informant 10)

4.3.2.3 Part 3

Open questions; Asking 14 members of the general public acting as stakeholders based on what they experienced in their own lives about the things that they found needed to be improved in the homes in which they live:

1) Homes are important to members of the general public and individuals provide many valuable perspectives. They feel comfortable and safe at home. Because the house is a place for them to rest. Functions and design relationships within the home are also important because aside from providing comfort and a feeling of safety, they also impact relationships within the family. Housing needs to be better designed to meet usage requirements and add extra value. There are common areas such as the main living area for them to do activities together which are confirmed in interviews as follows:

“Think of rest If we go home should be able to rest and don’t have any problems.”

(Single, key informant 7)

“Functional Design. Living area to meet the needs of all members of the family.”

(Couple with children, key informant 10)

“The important of home I think of family relationships within the home is very important.”

(Single, key informant 6)

“Being comfortable, there is a small space for us to walk around. Can plant, can sit and rest. I think the house can have many people. Can have family activities together.”

(Older couple, key informant 11)

“Depends on the design. At that time I built this house so I wanted the house to have energy saving therefore having to use heat insulation and use 2 layers of walls, it is a good heat protection.”

(Older couple, key informant 13)

“Depending on the demand of each members. No matter the excellence of the design if nobody uses it, it is useless. Technology and materials have to be useable and of reasonable cost.”

(Couple with children, key informant 10)

2) Another topic was that there are a lot of problems that happen in the dwellings of members in general public. The researcher found that the current homes that they live in have many problems which are mainly related to construction materials used and the design functions of the house that do not cover usage. Failure of construction materials after a long period of time was noted, such as a fracture of the ceiling that causes water to leak. Also noted was the use of inappropriately specified materials such as tiles on the floor of frequently used areas such as bathrooms, kitchens that are easy to slip on. There may be accidents because of slippery tiles. Another matter is the function design of houses that do not support occupant use as well as they could. The general thought was that designers should think of the day they may become an older person themselves and may have to add or alter the house a lot. It is the reason why the home perhaps cannot be used in the first place which is confirmed to the following interviews:

“I think it must be comfortable. Don't have to go up and down by the stairs. It must be safe If unable to walk, I would like a hand rail in the bathroom and the floor not to be slippery.”

(Couple without children, key informant 3)

“Convenient and horizontal area, convenient equipment and non-slip bathroom. I want to live in the midst of nature as a garden.”

(Single, key informant 6)

“The problem is from construction materials. Cracked flooring caused by prolonged use. The extension has water leakage that may be caused by a

material that is not strong enough. Slippery flooring... If possible, I would like to change the tile floor in the kitchen and bathroom to be anti-slip for the elderly, and for there to be a rail to prevent accidents. In the bathroom, I want to separate the dry and wet parts. Not the whole bathroom being wet. I would like to make a partition there. As for the stairs, I would like to make them strong and stable.”

(Older couple, key informant 11)

“The ceiling material is causing of leaking water, cracks from use for a long time. And not enough storage space... If I get older, I may have to move the bedroom to sleep on the ground floor. I may need additional convenience such as handrails or making ramps. That can support the use of accessories such as wheelchairs and have equipment that can support or help me in the event of an accident.”

(Single, key informant 7)

3) Therefore, the problem should be addressed. Beginning with planning the design of the dwelling with regard to users or members of the house. The house should have functions that can support its use by people of all ages. The use of construction materials, and the layout of the dwelling itself, are also a matter of consideration for the health and safety effects of life throughout every period of use of the house. Other than that, they focus on bringing in technology to use for the convenience which are conformed from the interviews as follows:

“I will use technology for improving the household and assisting when I get older, etc.”

(Couple with children, key informant 2)

“Bringing technology to help, using the materials that are long-lasting. No need for maintenance or changing frequently...The technology such as electric sliding door, electrical systems that are more responsive to use aside from

lighting. I want light suitable for reading or the light that is suitable for decorating the room and can be changed. Raised areas that can prevent flooding.”

(Single, key informant 7)

“I focus on using technology such as an elevator because I want to live upstairs. I want to have a cleaning robot. Maybe I will use the voice order system. There will be a warning sound when rain is approaching in case of having to wash clothes. An intelligent machine that can water the plants on time. And the last one is sensor lighting that can turn on and off automatic.”

(Older couple, key informant 11)

“I think about bringing technology to help, such as having an electric door with a light system coming in and opening by itself Is a sensor system house that is simple and not complicated.”

(Single, key informant 8)

“Try to avoid material asbestos unhealthy, glass fiber insulation is used for a long time, it will deteriorate and will be harmful to the lungs.”

(Older couple, key informant 13)

4.3.2.4 Part 4

Agreement level in order to assess the opinion regarding the quality and the environment in the housing.

The level of opinion interpretation is as follows:

- 1) Average 4.51-5.00 means Strongly agree
- 2) Average 3.51-4.50 means Agree
- 3) Average 2.51-3.50 means Neutral
- 4) Average 1.51-2.50 means Disagree
- 5) Average 1.00-1.50 means Strongly disagree

The result of evaluating the level of approval of members of the general public acting as stakeholders on the level of agreement of environmental impacts in the building. Found that the level of agree with a total average of 4.14

Table 4.2 Average of agreement level of members in the general public acting as stakeholders

Agreement level in order to assess the environment in the housing.	Members in public	
	Average	Agreements Level
Having good quality air to breathe increases both short-term and long-term wellbeing.	4.57	Strongly agree
Having increased contact with nature increases wellbeing.	4.00	Agree
Smarter designs of homes can help address many of the challenges we face from climate change.	4.07	Agree
The initial design of a dwelling should be flexible enough to easily enable changes to be made to it as occupants' circumstances change.	4.28	Agree
As mains frequency magnetic fields and radiowaves are Group 2B carcinogens (and many insurance policies do not provide over for them), design measures should be taken to help reduce occupants' exposures to these.	4.21	Agree
Indoor environments should be designed to help improve people's fertility levels.	3.71	Agree
Biologically improved buildings can help improve both long-term and short-term health.	4.28	Agree
Receiving good levels of daylight, including occasional sunlight, when indoors is important.	4.35	Agree
I have enough personal privacy when I need it in my home.	3.42	Neutral

Table 4.2 Average of agreement level of members in the general public acting as stakeholders (continue)

There is usually enough storage space in new homes.	3.78	Agree
There is enough space for easy storage of clothes horses, ironing boards, vacuum cleaners, rubbish bins and recycling bins in my home.	3.07	Neutral
It is important to design homes in ways that can increase the wellbeing of occupants.	4.64	Strongly agree
Having design guidelines on how to increase occupant wellbeing is important.	4.28	Agree
It is important for buildings to be designed in ways that enable people to live healthier, happier more productive lives.	4.42	Agree
More designers should be made aware on the effect of the design of the environment on wellbeing.	4.71	Strongly agree
Ratings on how good individual buildings are at contributing to user-wellbeing should be created and made easily available.	4.28	Agree
Smarter bio-friendly lifetime homes should be created as standard within Thailand.	4.35	Agree
The dwelling should have extra insulation to help reduce their energy use and keep people cool.	4.64	Strongly agree
People would pay for extra insulation if they knew how much it could save them.	3.78	Agree
Exposure to even low levels of light at night is linked with increased risks of cancer, obesity and depression. You think smarter design measures should be introduced to reduce such risk.	3.92	Agree
You are often disturbed by noise both within and outside your home.	3.64	Agree

Table 4.2 Average of agreement level of members in the general public acting as stakeholders (continue)

You consider sound insulation that important to improving the quality of your home.	4.57	Strongly agree
There should be nearby communally accessible areas outdoors for particular types of rubbish and reuse/recycling activities to help reduce waste.	4.28	Agree

A strongly level of agreement was found between the members of the general public acting as stakeholders on the following: It is important that more designers should know how the design of the environment can impact wellbeing (4.71); homes should have extra insulation to help reduce energy expenditure and keep people cool (4.64); it is important to design homes appropriately so they can help increase wellbeing (4.64); sound insulation is important for improving the quality of a home (4.57); having good quality air to breathe increases both short-term and long-term wellbeing (4.57).

Furthermore, they exhibited an average level of agreement that showed that they additionally agreed on the following statements: smarter bio-friendly lifetime homes should be created as standard (4.35); it is important to provide suitable exposures to sunlight and daylight (4.35); have nearby communally accessible outdoor areas for rubbish and recycling/reuse activities to help reduce waste (4.28); there is a need to create biologically-friendly buildings to help improve occupant health (4.28); it is important to have guidelines on how occupant wellbeing can be improved by better design (4.28); a rating system should be developed to indicate how good individual buildings are at contributing to the wellbeing of users (4.28); designs should be flexible enough to deal with users' changing needs (4.28); designing buildings to enable people to live happier, healthier, more productive lives is important (4.27); the need for design guidelines on how to reduce occupant exposures to electromagnetic pollution (4.21); smarter designs of homes can help address many challenges resultant from climate change (4.07); increased contact with nature is

beneficial to wellbeing (4.00); as exposure to even low levels of light at night is linked with increased health risks, design measures should be introduced to address this (3.92); there is usually enough storage space in new homes (3.78); people would pay for extra insulation if they knew how much it could save them (3.78); Indoor environments should be designed to help improve people's fertility levels (3.71); people are often disturbed by noise both within and outside their homes (3.64).

Summary

The evaluation of members of the general public acting as stakeholders with the level of agreement with the quality of the indoor environment that affects the well-being at the agreeing level $\bar{X} = 4.14$

4.4 Discussion of Survey Results

The results of the survey work undertaken clearly demonstrate that design professionals and members of the general public are each strongly agreed on the points that it is important to design homes in ways that can help increase the wellbeing of their occupants, and that designers should be far more aware of how the design of the environment can influence wellbeing. They also strongly agreed and that dwellings should have extra insulation to help reduce the energy they use to help keep those within them cool.

Furthermore, the design experts strongly agreed that ratings on how good individual buildings are at contributing to health and wellbeing should be created and easily available for reference, and that there should be areas nearby dwellings for rubbish and reuse/recycling activities in order to help more efficiently reduce waste.

4.4.1 Blueprint for Developing Smarter Lifetime Homes that Enhance Wellbeing for All Generations

This blueprint concentrates on some of the factors that are considered to be of greatest importance by experts and members of the general public for achieving the above aim. It discusses these in order of the level of importance that

was given to them by the survey participants, and provides information on how these may be addressed through the adoption and blending of both intelligent system and by design approaches.

1) Environment and Wellbeing (5.00 & 4.71):

Recommendations: More designers should be made aware on the effect of the design of the environment on wellbeing.

Create a full set of design guidelines on 'Developing Smarter Lifetime Homes that Enhance Wellbeing for All Generations'. Have this set of guidelines being constantly updated as new information becomes available. In order to be a relevant guideline for practice in terms of living and creating a good environment both physical and mental wellbeing, in our ever-changing world.

2) Air Quality (5.00 and 4.57)

Having good quality air to breathe increases both short-term and long-term health and wellbeing (Jamieson et al., 2010; Garrod, 1944). It also increases cognitive performance (Allen et al., 2016). It is important to design smarter lifetime homes that take these findings into account.

Smarter lifetime homes should be designed so that they have very low VOC levels (as a result of good material and product specification), and that high outdoor air ventilation rates are used in areas of the home at the times they are occupied. The additional factors indoor air pollution are:

1) Emissions from combustion of solid fuels caused by burning wood, coal or other solid fuels such as burns from cooking which these dust causes pollution in the air. If inhaled, it may cause health effects such as stroke, pneumonia, lung cancer and heart disease (World Green Building Council, 2016-2020).

2) Biological contaminants caused by the air that can penetrate from the cracks in the building's wall. Causing moisture in the air which leads to the growth of mold in the air. Adversely affecting health makes the risk of asthma as high as 40% (World Green Building Council, 2016-2020).

3) Volatile organic compounds (VOCs) Volatile substances released from general products both solid and liquid which can adversely affect health. There

may be headaches, nausea and, moreover, may result in the risk and suspect link to cancer that is harmful to health (World Green Building Council, 2016-2020).

Causes of indoor air pollution

- Poor ventilation
- Furnishings
- Toxic building materials
- Occupier activities
- The relationship between outdoor and indoor pollution

Additionally, in particular the microenvironments that individuals occupy within rooms should have low electric field levels, as areas with raised electric fields typically have higher concentrations of charged $PM_{2.5}$ that are detrimental to health (Jamieson 2020a). In order to further help improve indoor air quality, it is recommended that smarter lifetime homes adhere to the Russian Ministry of Health Protection's SanPiN (2003) guidelines on air ion levels, particularly in microenvironments that are regularly occupied.

Table 4.3 Indoor air quality standard standards in accordance with the notification of the Department of Health on the criteria for indoor air quality monitoring criteria

Air quality factors	Recommended value
Thermal comfort conditions	
Temperature	20-26 °C
Relative Humidity	50-65 %
Air Movement	0.1-0.3 m/s
Ventilation	2-10 m ³ /hr/m ²
Indoor air pollution	
Carbon dioxide	< 700 ppm.
Carbon monoxide	< 9 ppm.

Table 4.3 Indoor air quality standard standards in accordance with the notification of the Department of Health on the criteria for indoor air quality monitoring criteria (continue)

Particulate Matter with diameter less than 2.5 micrometers: PM _{2.5}	< 35 µg/m ³
Particulate Matter with diameter less than 10 micrometers: PM ₁₀	< 50 µg/m ³
Ozone	< 0.1 ppm.
Formaldehyde	< 0.1 ppm.
Volatile Organic Compounds: VOCs	< 3 ppm.
Fungii	< 500 CFU/m ³
Bacteria	< 500 CFU/m ³

Indoor air quality standard standards in accordance with the notification of the Department of Health on the criteria for indoor air quality monitoring criteria. Indoor air quality standards according to SS554: 2009 Code of Practice for Indoor Air Quality for Air-Conditioned Buildings of SPRING Singapore.

Source: Buildings SPRING Singapore, (2009)

3) People-Friendly Buildings (5.00 & 4.42):

Recommendations: Smarter lifetime homes should be designed in ways that enable people to live healthier, happier more productive lives.

There is a need for greater awareness on design factors that can better enable this. More effort should be made to tap into the opportunities to create more biologically-friendly smarter-designed environments that can help enhance lifelong wellbeing and performance throughout all stages of life.

4) Design homes so that they can better help increase wellbeing (4.88 & 4.64):

Recommendations: Both intelligent system and by design approaches can be blended together help achieve this aim. As examples, the use of humidity control devices, air detectors and toxins control or in a way that does not

use technology, it is used to plant trees in buildings. To help filter out toxins and can increase the humidity in the air (But must be increased at an appropriate amount and not harmful to breathe) and physically such as using an electric utility to help lift the wheelchair or using elevators to help wheelchair users go up into different levels of space. But on the other hand, being able to use different areas without using technology for help is also important. Simple low-cost solutions can often be created through undertaking good bio-friendly design initiatives. These can be designed to provide the right space for every use limitations. The use of tools to control air quality, lighting, wind power, and heat is not necessary if the design is correct from the direction of rotation will help in terms of heat and wind, designing to have sufficient light intake to use at the correct times of day. All related to the design, which can help to improve well-being.

5) Dwelling designs should be flexible enough to deal with users' changing needs (4.88 & 4.28):

Recommendations: Again, both intelligent system and by design approaches can be used to help ensure this. One of the most basic smart design approaches that can be adopted to increasing flexibility of use is to ensure that spaces are of suitable dimensions and materials to enable likely changes to be made.

6) Have smarter design guidelines on how to reduce occupant exposures to electromagnetic pollution (4.75 & 4.21):

Recommendations: As extremely low frequency magnetic (ELF) fields and radiowaves are recognised as Group 2B carcinogens (IARC, 2002; WHO & IARC, 2011), and research shows that raised electrostatic fields from the frictional charging of materials and mains-frequency electric fields from electric items can increase local concentrations of contaminants in indoor microenvironments (Jamieson 2020a; Jamieson et al. 2010); it is recommended that the designers of smarter lifetime homes and smarter technologies should actively seek to reduce occupant exposure to such pollution, and ideally seek to create biologically beneficial exposures to electromagnetic phenomena.

Designers should be made more aware of best practice measures that they can adopt to reduce possible risks. Examples:

1) Reduce the use of wireless devices to reduce the emission of various signals. Switch to the installation of hard-wired connections for equipment such as computers and the use of landline phones. The use of potentially safer high-tech solutions for wireless connectivity, such as LiFi, which uses light to transmit data (PureLiFi, 2020), should also be considered.

2) Installed all electrical appliances, electronic devices far from the body as much as possible. Moreover, it should be very far from the resting point. Such as beds, sofas, should not have various electrical appliances near to reduce the rate of release of signals into the body and very important for the head of the bed. It must avoid installing all types of electronic equipment including cables in the well.

3) Installing a wired internet is a necessity in every room. In order to reduce the use of wireless waves that can send signal waves to affect our body.

4) Before building housing must have an electromagnetic wave measurement around the area. And should check the electromagnetic wave continuously during operation including when the building is completed. If at any point there is an electromagnetic interference, use such a signal blocker to be safe and do not send a signal to be harmful to health.

The layout of individual dwellings, the likely location of items of furniture and electrical equipment within them, and the actual specifications of such items, can all greatly affect the levels of exposure to electromagnetic pollution that individuals receive (Table 4.4). The size of fields emitted is primarily dependent on the type of item in use (Table 4.4).

Table 4.4 Magnetic field of Electrical appliances in the household Appliance

Electrical appliances in the household Appliance	Magnetic field (μT)		
	Distance of 3 centimetres	Distance of 30 centimetres	Distance of 1 metre
Hairdryer Electric shaver Drill	6 – 2000	0.01–7	0.01 – 0.3
Electric shaver	15 – 1500	0.08–9	0.01 – 0.3
Drill	400 – 800	2–3.5	0.08 – 0.2
Electric saw	250 – 1000	1–25	0.01–1
Vacuum cleaner	200 – 800	2–20	0.1–2
Washing machine	0.08 – 50	0.15–3	0.01 – 0.15
Clothes dryer	0.3 – 8	0.1–2	0.02 – 0.1
Clothes iron	8 – 30	0.1 – 0.3	0.01 – 0.03
Kitchen appliances Appliance	Magnetic field (μT)		
Electric cooker top	1-50	0.15-8	0.01-0.04
Microwave oven	40-200	4-8	0.25-0.6
Refrigerator	0.5-2	0.01-0.3	0.01-0.04
Coffee machine	1-10	0.1-0.2	0.01-0.02
Hand-hoeld mixer	60-700	0.6-10	0.02-0.25
Toaster	7-20	0.06-1	0.01-0.02

Source: Swiss Agency for the Environment, Forests and Landscape, (2005)

The EUROPAEM EMF Guideline 2016 (Belyaev et al., 2016) recommends that in areas where individuals spend >4 hours per day, extra-low frequency (ELF) magnetic fields exposures should not exceed the values shown in Table 4.5

Table 4.5 Precautionary guidance for ELF magnetic field exposures

ELF magnetic field	Daytime exposure	Nighttime exposure	Sensitive populations
Arithmetic mean (AVG)	0.1 μT	0.1 μT	0.03 μT
Maximum (MAX)	1 μT	1 μT	0.3 μT

Source: Belyaev et al., (2016)

It is important for designers to be aware that magnetic fields can easily pass through most building materials, and also that their field strength quickly diminishes with distance (Jamieson, 2020). This is especially important in terms of liability, as many insurers now refuse to provide cover on issues related to electromagnetic fields (Jamieson, 2019).

7) It is important to have guidelines on how occupant wellbeing can be improved by better design (4.75 & 4.27):

8) Increased contact with nature is beneficial to wellbeing (4.75 & 4.00):

Recommendations: Increase the presence of vegetation in and around buildings. This includes considering the possibility of making provision for planting on balcony area and having window boxes, and allowing space for vegetation in key areas indoors too.

The increased presence of vegetation can additionally help increase wellbeing by both helping filter the air and helping reduce local temperatures.

9) It is important to provide suitable exposures to sunlight and daylight (4.63 & 4.18):

Recommendations: Try to ensure that individuals get adequate exposures to unfiltered sunlight and daylight. It is especially beneficial for appropriate exposures to be received at the beginning of the day. The light can make the occupants feel increased levels of enthusiasm, creativity and productivity (Human Spaces 2014). The higher levels of daylight exposure are associated with improved memory recall, mental function and task performance (Loftness et al., 2009). Green buildings use as much light from the Sun as possible to reduce energy usage and provide a comfortable environment for occupants

Suitable lighting provision in green buildings combining the best methods of natural and artificial lighting not only improve the health and satisfaction of occupants but also improve their work efficiency and productivity (Ghodrati et al., 2012). Factors worth being aware of, especially as more people are starting to work from home. Even smarter, more biologically-friendly, lighting exposures can be created.

Table 4.6 The window sizes for working and learning spaces

Area	Window/wall ratio as measured on external elevations
Working and Learning Spaces	Between 40% and 60% of window area is at least 2.1 m above the floor.
Living room	Between 30% and 60%
Bedroom	Between 20% and 40%

Source: standard.wellcertified.com, (2020)

Table 4.7 The promoting exposure to daylight can be from a window or atrium

Area	The following requirement
Lease depth	75% of the area of all regularly occupied spaces is within 7.5 m of view windows.

Source: standard.wellcertified.com, (2020)

Balconies: Design balconies that are no smaller than 300 cm by 180 cm otherwise they are unlikely to be used for recreational purposes. Consider having balconies on facades with different orientations so that people can sit outdoors in the shade at different times of the day.

**Figure 4.1** Balconies

Source: Kamolchaiwanich, (2020)

Making provision for plants to be easily grown there to increase contact with nature, and provide extra privacy if required. Ensure that balconies are reasonably private by providing space, side wings, or vegetation buffers.

A novel alternative to the traditional balcony, that is suggested by Jamieson (2019, 2020) (Figure 2.5.23:), is to have fully retractable glazing along above normal handrail height in rooms to help easily convert closed living space to areas that are more in contact with the outdoors.

10) Ratings on how good individual buildings are at contributing to user-wellbeing should be created and made easily available (4.63 & 4.27):

Recommendations: These should be created at the earliest possible opportunity. It is hoped this present work will act as a catalyst for this important work to be undertaken. The ratings should reflect how buildings can affect well-being and help provide guidance for residents on measures that they themselves can take to help prolong their own health and wellbeing.

11) Have nearby communally accessible outdoor areas for rubbish and recycling/reuse activities to help reduce waste (4.50 & 4.36):

Recommendations: The residence has a central area that is accessible for garbage disposal and recycling. It will help to be more comfortable in living, reduce the accumulation of germs in the home and also helps to encourage people to turn to recycling waste as well and live more sustainably.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

As mentioned at the beginning of this thesis, the Global Wellness Economy is currently worth \$4.5 trillion (Global Wellness Summit, 2019), and the Global Wellness industry is now one of the largest and the fastest growing industries in the world, having exhibited 17.8% growth since 2015. Having, obtaining and retaining good health are things that many people now realise are important, and this trend looks set to continue. More members of the general public are starting to realise how the environments they live in can affect their health for good or bad. This awareness appears to have dramatically increased as a result of the COVID-19 pandemic.

Therefore, modern homes may not now just be considered on first appearances, but as environments that can impact our wellbeing as a result of their design, layout and the actual specifications and usage of the materials and technologies within them. So, if designed correctly, they can help meet the increased health and wellbeing needs of users. How effective buildings are at doing this could become major selling points in the future.

The main findings made from undertaking research in this topic area have indicated the factors that design professionals, with expertise in health and wellbeing building design, and members of the general public, representative of buyers on the housing market, consider to be of the greatest importance for the creation of smarter lifetime homes that enhance wellbeing for all generations.

It is proposed that there is an urgent need for best practice guidelines that take such factors into account to be developed at the earliest possible opportunity. This proposal has already received a strong level of approval from design professionals and members of the general public that have acted as stakeholders in this present work. As mentioned earlier, it is hoped that this present work will act as a catalyst for this to be done. Having ratings to reflect how buildings can affect well-being could help substantially influence how they are designed and provide a new growth area for

industry.

It is for this reason that it is hoped that the findings, be taken as a blueprint to develop just such an independent, cross-professional body initiative in Thailand. Further research is required to be undertaken to illustrate the levels of benefits, both financial and otherwise, that can be obtained from such an initiative, and the need for more designers to become aware of the possible impacts of the design decisions they take. Ideally such best practice measures would be accepted as the ‘new norm’ for building works.

5.1 Key Findings

This research revealed that design professionals focused most on the issue of increasing the design flexibility of projects in order to better meet the potentially changing needs. They also recognised the important role that specification of the right types of technology can play in creating safer and healthier environments.

From the overall feedback they gave, the top three factors they considered needed to be taken into account in order to create smarter lifetime homes are: good air quality; designing buildings to enable people to live happier, healthier, more productive lives; and the need for more designers to become better educated and aware of how the design of the environment can influence life quality, health and wellbeing.

They also strongly agreed on the need for good exposure to natural light; and the need to reduce occupant exposure to electromagnetic pollution. Furthermore, it was encouraging to note that they also strongly agreed on the importance of creating guidelines that demonstrate how designers can help increase the wellbeing of individuals through the design decisions they make.

With regard to members of the general public, it was found that their greatest concern was related to the actual structural integrity of dwellings as related to their planned usage, and the convenience factor related to how they could be used and adapted. The convenience factor provided by the introduction of technology into

the home was also highlighted. They displayed less concern than the design experts that both mains frequency magnetic fields and radiofrequency fields are Group 2B carcinogens. This was despite the fact that, like those experts, they strongly agreed that designers should be better aware of how the design of the environment can impact health and wellbeing. There was little awareness that safer technologies that reduce electromagnetic pollution risks can often be easily obtained.

Additional top factors that the members of the public strongly agreed on were: the need for better thermal insulation and sound insulation in dwellings. Surprisingly, it was observed that few of the members of the general public that took part in the questionnaire survey were aware of the importance of good indoor air quality to help maintain and improve quality of life, health and wellbeing. Instead, they considered far more tangible factors, such as the importance of using good quality materials and having designs that respond appropriately to their intended use. It is heartening to note that though they generally initially considered indoor air quality to be of little real relevance to them; once the importance of good air quality was explained to them, in terms of how it could help improve their physical health, mental health and safety, they also agreed with the experts about its value.

5.2 Strengths and Weaknesses of This Research

5.2.1 The Strengths of This Research

This research addresses the needs and benefits of creating more biologically friendly housing stock in order to develop smarter lifetime homes that enhance health and wellbeing for all generations. This is a particularly appropriate issue for Thai society as it enters into an aging society, and greater awareness is arising of the benefits of people being able to retain good health and their independence for as long as possible.

It is also a very important area of research to pursue because of the substantial growth of interest in this field, and that fact that very few designers are presently aware of the fact that far more biologically-friendly smarter buildings can be

created as lifetime homes, particularly if the right areas of expertise are brought together. The findings from this present work can be applied to the design of buildings today and developed even further to create even more benefits.

This research has benefitted from receiving the valued inputs of many experts. People who have detailed knowledge of residential design and the kinds of environmental conditions in the home that will help promote well-being, keep people in good health, create a comfortable environment for all individual. The input that has been received is greatly appreciated and substantially improves the worth of the findings.

This present work has brought together and assessed a wide variety of often seldom considered factors that can affect wellbeing in the home, and whether projects will work successfully as Lifetime Homes. Indoor environmental factors such as air quality, toxin loads, optimised light exposures, contact with nature, temperature ranges and relative humidity levels, all have important roles to play in both the physical and mental wellbeing of occupants. They can also affect individual's levels of comfort, safety, fatigue, and productivity (Hwang et al., 2011). These are matters that designers should be far more aware about. The present work suggests how this can be achieved.

This research brings together knowledge and understanding on how to create safer, more biologically-friendly smarter Lifetime Homes. It looks upon blending intelligent system and by design techniques to achieve this. It can be used as a starting point to create best practice guidelines, as related to design principles and specifications, that aim to create better housing that seeks to actively promote good health, slow down the aging of the body and reduce the risk of developing various diseases. Ideally its findings and the measures its proposes could be used as standard when building and renovating houses in Thailand to help improve the health of the nation.

5.2.2 The Weakness of This Research

The study was conducted during the COVID-2019 crisis which caused restrictions in how experts and members of the general public could be interviewed. The in-depth expert interviews had to be conducted online, and finding members of the general public to act as stakeholders and take part in online interviews was difficult. Finding key informants within the general public that could represent key stakeholder groups presented a major issue that weakened the findings of the results.

Another point that is important to mention is that during the interviews with the members in general public it became evident the majority of them needed to have detailed background information provided to them before they could make informed decisions. As examples, many were unaware of the effects that environmental factors such as air quality, daylight exposures, electromagnetic pollution, and light at night can have on their health and wellbeing. Most people have not been educated on such matters and therefore generally pay little attention to them. Such general lack of knowledge also typically extends into issues related to the Lifetime Homes concept and the possibility of individuals being able to use their homes without restriction throughout most of their lives. As a result, the information obtained from interviews with members of the general public primarily comes from their direct experiences encountered within their own homes, often with regard to the original house structure and the materials used within it.

Assessing the actual strengths and weaknesses of designs, and components of designs, was another weak point of the research because doing so requires knowledge of design and best and worst practices, and the researcher is still on a learning curve with regards to this. Therefore, the researcher has to study further to become more efficient in this field. To help address this shortfall, data and information was gathered on relevant design factors that provide good indicators of environmental quality as related to residential design in order to help achieve the goals of the research concerning the well-being, good health of the residents of all ages.

5.3 Future Research Needs.

It is proposed that in the future far more multi-disciplinary research is required to create more biologically-friendly smarter lifetime homes. It should cover the following aspects:

1) Best practice bio-friendly design, including optimising smarter design layout and specifications used within dwellings.

2) In-depth study of how to merge both intelligent system and by design approaches to achieve such aims both indoors and outdoors for people at all stages of their life journey.

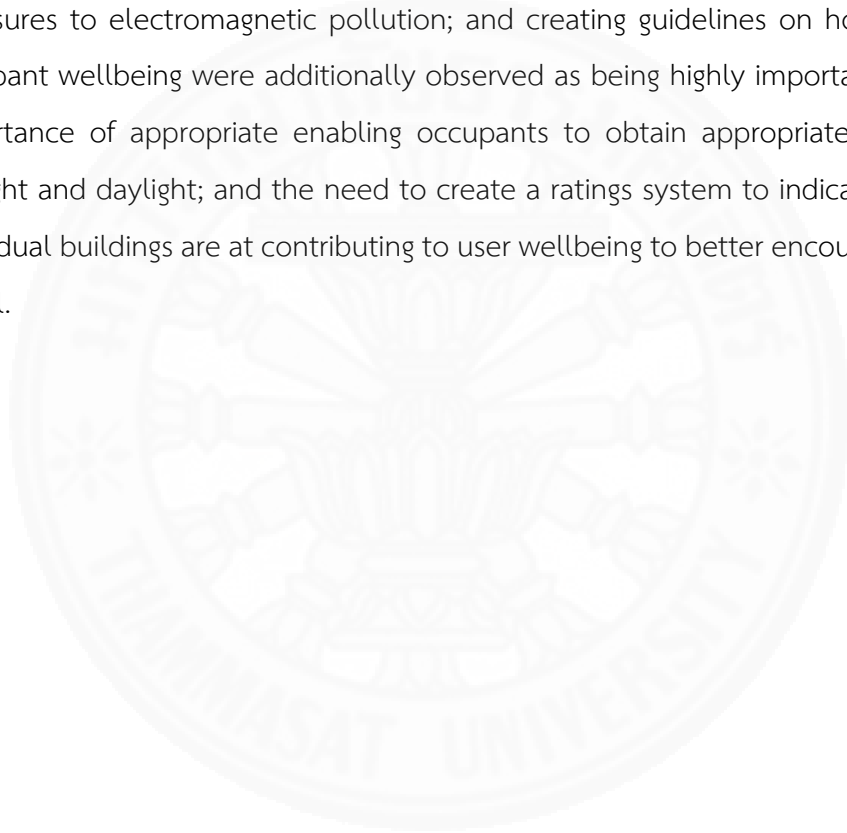
3) In education and identification of challenges to be addressed, it should take into account a wider range of opinions from stakeholders, in order to better see the needs of the people in their entirety. Such information should be used to continually refine best practice guidelines to increase their effectiveness and help drive innovation.

4) Additionally, this work needs to be extended and refined so that its findings can be applied all over Thailand.

5) It is proposed that this biologically-friendly smarter lifetime homes concept should be further expanded so that it can be used anywhere in the world as standard.

6) Cost Benefit Analysis. To assessment cost-effectiveness of this project. In which this project evaluates the value in money might be difficult to estimate, as housing development can help reduce the risk of causing harm to health, stress, discomfort, both physical and psychological.

In summary, as reported by Kamolchaiwanich et al., (2020), it was observed that the design experts all strongly agreed that: More designers should be aware of how design can affect wellbeing; the need for good air quality; and the importance of designing buildings to enable healthier lives. They also strongly agreed on the need to create biologically-friendly buildings and design homes to increase health, wellbeing and life-quality, plus having designs that are flexible enough to meet the changing needs of their occupants. The benefits of increasing contact with nature; reducing exposures to electromagnetic pollution; and creating guidelines on how to increase occupant wellbeing were additionally observed as being highly important, as was the importance of appropriate enabling occupants to obtain appropriate exposures to sunlight and daylight; and the need to create a ratings system to indicated how good individual buildings are at contributing to user wellbeing to better encourage wellbeing for all.



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APPENDICES



APPENDIX A

QUESTIONNAIRE

DEVELOPING SMARTER LIFETIME HOMES THAT ENHANCE WELLBEING FOR ALL GENERATIONS: QUESTIONNAIRE CONSENT TO PARTICIPATE IN RESEARCH

Interview session for design professionals with expertise in health and wellbeing building design: The investigation of related factors leading to the development of smarter lifetime homes that enhance wellbeing for all generations in Thailand.

Introduction and Purpose:

My name is Miss Suthida Kamolchaiwanich, and I am a master student in Design Business and Technology Management at the Faculty of Architecture and Planning at the University of Thammasat. I am working with my faculty advisor, Dr. Isaac Jamieson, an International Expert within the Department of Business and Technology Management Program on this present study investigating how to develop smarter lifetime homes that enhance wellbeing for all generations. I would like to invite you to take part in my research on this.

Procedures

This interview is comprised of 4 sections:

- I. General Information (12 questions)
- II. Background and main research questions (4 questions)
- III. Open questions (18 questions)
- IV. Level of agreement (17 issues 23 questions)

If you grant your permission, I would ask for audiotaping and taking any notes during the interview for clarity. The recording is to accurately recording the information you provide, and will be used for transcription purposes only. Otherwise in the case that the audiotaping is not permitted, I will take notes instead. If you agree to being audiotaped but feel uncomfortable at any time during the interview, I can turn off the recorder upon your request. Or if you don't wish to continue, you can stop the interview at any time.

Confidentiality:

All the information gathered from this interview is handled as confidentially as possible. If results of this study are to be published or presented, individual names and other personally identifiable information will not be used unless the interviewee gives explicit permission for that to be done.

The information gathered in this interview would be used for educational purposes only.

Signature..... Date

Part I: General Information: Personal information about key informant

Please tick all appropriate boxes:

1. Gender Male Female

2. Generation

Post-Millennials or Generation Z: Born 1997-Present (0-23 years old)

Millennials or Generation Y: Born 1981-1996 (24-39 years old)

Generation X: Born 1965-1980 (40-55 years old)

Baby Boomers: Born 1946-1964 (56-74 years old)

The Silent Generation: Born 1928-1945 (75-92 years old)

3. Status

Single

Engaged

Married

Prefer not to answer

4. Education level

Primary School

Secondary School

Bachelor's Degree

Master's Degree

Other (Please state)

5. Career

Student

Civil servant / state employee

Business Owner

Freelancer

Housewife / Househusband

Private company employee

Other (Please state)

6. Location, where do you live?

Bangkok District / Area.....

Perimeter Country..... District / Area.....

Provincial Country..... District / Area.....

Other (Please state)

7. Do you have children?

Yes

No

8. If you have children, how old are they?

.....

9. If you have children, do they live with you?

Yes

No

10. Do you live with your parents?

Yes

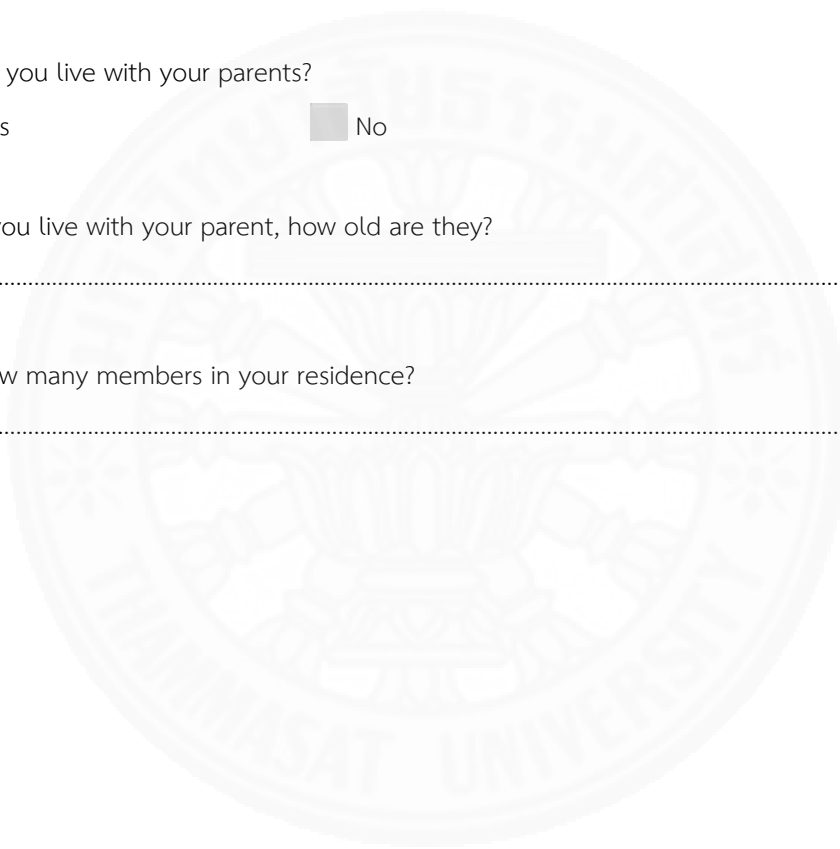
No

11. If you live with your parent, how old are they?

.....

12. How many members in your residence?

.....



Part II: Background and main research questions:

2.0 Background

Wellbeing is now a \$4.5 trillion industry. Though the design of the built environment can affect wellbeing, the building industry has still to properly tap into the opportunities it has to create more biologically-friendly smarter-designed environments that enhance lifelong wellbeing.

The feedback you give to the following questions will help reveal what the building industry can do to address this matter and help enhance wellbeing for all.

2.0.1 What do you think about Lifetime Homes?/ What is the meaning of LifetimeHomes?

.....

2.0.2 In your opinion what does wellbeing for all generations in term of housing should be?

.....

Main research questions

2.1: How can we develop smarter lifetime homes that enhance wellbeing for all generations?

.....

2.2: How does the design of dwellings, and the technologies and materials used within them, impact user satisfaction and wellbeing, and how can a smarter approach help enhance lifelong wellbeing all stages of life?

.....

Part III. Open questions

Asking based on what participants experienced in their own lives. That they live in the house and found that things need to be improved. What can be changed in their houses?

What is important to you in your home?

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.....
.....

What is in the design of your home that could have been done better?

.....
.....
.....

What is the most common problem in your home?

.....
.....
.....

Who is it that usually have a problem (or accident or not is not satisfied) with your home? Please explain the reason (if you know)

.....
.....
.....

Where do you usually have a problem, difficulty, accident or an area you are not satisfied with in your home? Please explain the reason (if you know)

.....
.....
.....

What do you value most about where you live?

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.....
.....

What do you like least about where you live?

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.....
.....

What would you like to be improved most in where you live?

.....
.....
.....

How do you think your needs will change as you get older?

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.....
.....

What smarter improvements would you like to see for it?

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.....
.....

What are your views on developing smarter lifetime homes that enhance wellbeing for all generations?

.....
.....
.....

Would you like to live in a home that was specifically designed to help make you healthier and remain healthier longer?

.....
.....
.....

What do you think of the concept of freely providing best practice design details and specifications showing how healthier homes can be created?

.....
.....
.....

Promoting and improving well-being for all generations in terms of housing:

What do you think about this concept?

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.....
.....

Do you think it could increase the sell ability and rent ability of dwellings?

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.....
.....

How much extra do you think such a property would be worth compared to standard?

.....
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.....

What are the design factors that you are already aware of that can improve the quality of life of the occupants?

.....
.....
.....

Do you think that more people should be aware of such design factors?

.....
.....
.....

Part IV. Level of agreement Agreement level in order to assess the opinion regarding the quality and the environment in the housing.

No.	Statement	Level of agreement				
		Strongly Agree (5)	Agree (4)	Neutral (3)	Disagree (2)	Strongly Disagree (1)
Indoor air quality						
1	Having good quality air to breathe increases both short-term and long-term wellbeing.					
Biophilia						
2	Having increased contact with nature increases wellbeing.					
Climate change						
3	Smarter designs of homes can help address many of the challenges we face from climate change.					
Design flexibility						
4	The initial design of a dwelling should be flexible enough to easily enable changes to be made to it as occupants' circumstances change.					
Electromagnetic pollution						
5	As mains frequency magnetic fields and radiowaves are Group 2B carcinogens (and many insurance policies do not provide over for them), design measures should be taken to help reduce occupants' exposures to these.					
Fertility						
6	Indoor environments should be designed to help improve people's fertility levels.					
Health						
7	Biologically improved buildings can help improve both long-term and short-term health.					
Light						
8	Receiving good levels of daylight, including occasional sunlight, when indoors is important.					
Privacy						
9	I have enough personal privacy when I need it in my home.					

Storage						
10	There is usually enough storage space in new homes.					
11	There is enough space for easy storage of clothes horses, ironing boards, vacuum cleaners, rubbish bins and recycling bins in my home.					
Wellbeing						
12	It is important to design homes in ways that can increase the wellbeing of occupants.					
13	Having design guidelines on how to increase occupant wellbeing is important.					
14	It is important for buildings to be designed in ways that enable people to live healthier, happier more productive lives.					
Effects of design on wellbeing						
15	More designers should be made aware on the effect of the design of the environment on wellbeing.					
16	Ratings on how good individual buildings are at contributing to user-wellbeing should be created and made easily available.					
Lifetime Homes						
17	Smarter bio-friendly lifetime homes should be created as standard within Thailand.					

4) Finally, are there any other relevant factors that should be realized? What issues should be developed?

.....

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Thank you for your participation in this survey.



APPENDIX B

ADDITIONAL FACTORS THAT SHOULD BE CONSIDERED FOR INCLUSION IN FUTURE GUIDELINES FOR DEVELOPING SMARTER LIFETIME HOMES THAT ENHANCE WELLBEING FOR ALL GENERATIONS



1. Flooring finishes

- 1) Light coloured floor finishes can increase the amount of light throughout the area.
- 2) Hard floors may hinder performance and confidence in walking. In a study of 58 hospitalised patients it was shown that carpeting can improve walking speed, stride length and walking confidence (Willmott, M., 1986).
- 3) When carpet is used for areas with wheelchairs it should not be higher than 0.5 cm.
- 4) Carpeting with antimicrobial systems will help prevent the growth of microbes and odors.

- 5) Those who are allergic to dust should not have carpets.
- 6) If carpeting is to be used, it should permanently fixed to help prevent trip or wheelchair risks.

2. Windows

- 1) Both the window design and the position of the controller should be accessible to children and wheelchair users.
- 2) The angle of the sill must be rounded to prevent injury.
- 3) For security, choose windows and doors that won't swing in by the wind.
- 4) Reducing the height of the window, or designing in overhangs or canopies can reduce the sun exposure.
- 5) The double sliding window can save energy but may require a lot of power to use. It may not be suitable for people with strength limitations.



3. Doors

- 1) Exterior sliding doors may be difficult to use due to the width and weight of each door. In addition, the accumulation of dirt in the door rails can cause the door to not work.

3.1 Internal door openings

- 1) Sliding doors are a good option for wheelchair users.

- 2) Hanging top sliding door may be easier to move than a sliding door on the bottom rail. Choose nylon wheels or roller bearings with self-lubricating metal.
- 3) All interior and sliding doors should have a push force less than 2.268 kilograms of force.
- 4) Recommended clear opening 90 cm (a minimum clear opening of 84 cm is only acceptable if unavoidable).

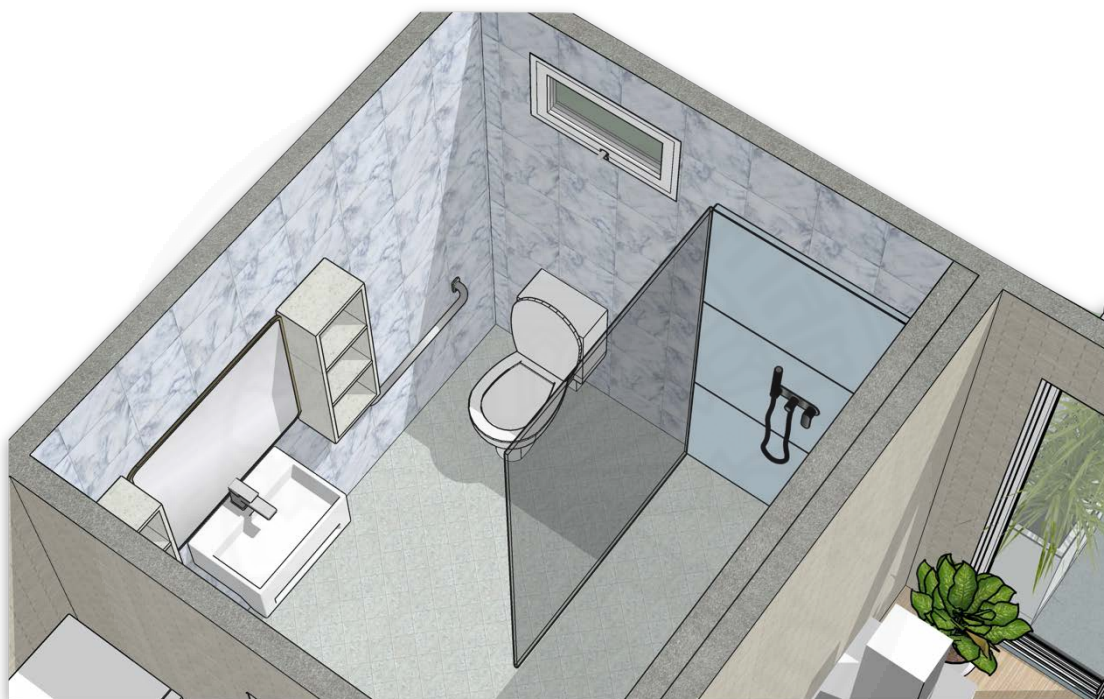
4. All passageways

- 1) Minimum 120 cm width clear of obstructions.

5. Lighting

- 1) The entrance of dwelling should be thoroughly exposed to light. A good position for lamps is the side or top of the entrance which can shine through the doorway. If the entrance has well lit, it will be able to identify who wants to enter the house or visitor.
- 2) Sufficient lighting is especially important in areas that require concentration such as lounges and entrances may require more light. Light ceiling colour will increase the amount of light reflected.
- 3) Many accidents occur in the bathroom. Increase the light level to prevent accidents.
- 4) Stairways can be dangerous areas. Add light or windows to allow light to shine through the stairs. Underfoot lighting can prevent accidents without creating glare.
- 5) When the amount of light increases, be careful not to overheat.
- 6) Lighting is useful when using a shower chair or seat. A room filled with steam makes it harder to see, and high ceilings may not be able to shine at the level of a shower seat. At least install a vapour proof lamp on the ceiling of every shower cabinet. The light can be combined with the exhaust fan to reduce water vapour.
- 7) Avoid using neon lights. Because flashing neon lights cause seizures and studies have shown that people with Alzheimer's disease develop anxiety under neon lights.

- 8) Cool fluorescent light or bluish-green tones is the hardest for people with cataracts to recognize.
- 9) When use the fluorescent light, be aware that the closest light spectrum possible during the day may reduce depression, fatigue, hyperactivity and the incidence of certain diseases. Daytime light waves may increase calcium absorption and response to light and sound.



6. Showers

- 1) All members can use the general shower, including wheelchair users. And a shower must be a minimum of 75 to 150 cm.
- 2) The floor of the shower room should be sloping so that water flows into the drain.
- 3) If the steep slope of the floor over 2 percent, makes it difficult to make a wheelchair for bathing.
- 4) The shower should have rounded corners both inside and outside for safety and ease of maintenance and the floor should be non-slip.
- 5) Providing every shower with adjustable hand shower. This system is suitable for wheelchair users.

- 6) The shower hose should be at least 150 cm long, but some users may need a 180 cm long hose.
- 7) Choose a shower model that has a button to control the water level in the shower.
- 8) Shower shelf can prevent soap, shampoo and accessories from getting out of hand. Choose one of brass, plastic or stainless steel to prevent corrosion and rust. Make sure that it drains easily.
- 9) WCs should have a clear space of 110 cm in front and 70 cm to one side to allow for a wheelchair user to ambulant.
- 10) Bathrooms should be designed to incorporate ease of access to the bath, WC and wash basin.
- 11) Bathroom layouts should indicate an area 100 cm x 100 cm for a shower (which may overlap with a bath) to allow an accessible shower to be installed in the future.
- 12) Walls in bathrooms and WCs should be capable of taking adaptations such as handrails. Wall reinforcements should be located between 30 and 150 cm from the floor.

7. Toilet

- 1) Bathrooms that have a long layout are easier to use than standard sizes used when transferring or aligning with a shower wheelchair.
- 2) Should have a seat to adjust the height of the wheelchair for adults and children (25-50 cm).
- 3) The flush valve lever should be on the wheelchair side. The bathroom should be flush easily without using energy more than 2.268 kilograms of force (5 pounds of force). It may be necessary to extend a portable toilet rod. Or use a sensor for automatic flushing.
- 4) Must have a clear space of 75 to 120 cm in front of toilet.
- 5) The toilet should be installed on the wall at least 35 cm from the wall.

8. Flooring

- 1) Non wax sheet vinyl flooring is a good choice for areas that may need frequent cleaning. The product is attractive and floor maintenance costs offer

savings over waxing for materials. However, lifetime cost analysis should include conditioning or replacement all the time.

- 2) The floor covering is provided it should be a material with high friction and low glare. Slippery and polished surfaces should be avoided.

8.1 Design Intervention

- 1) Should use materials with low VOC.
- 2) Avoid high contrast patterns in floor coverings especially for people with low visibility.
- 3) Floor colours and wall colours should intersect. To emphasize the edge of the room and to prevent collisions and accidents while sitting.
- 4) Alternatively, ceramic tiles, plating wood, rubber, and solid vinyl flooring can be used.

8.2 Appearance

- 1) The flooring with a high percentage of vinyl resins are the most resistant to stains.
- 2) Rubber flooring and vinyl flooring that is strong, durable and the best impact resistance.
- 3) Solid vinyl flooring with a large proportion of vinyl is the best choice for resistance.
- 4) Solid colour vinyl and embedded patterns are more resistant to scratches than vinyl prints.

8.3 Slip Resistance

- 1) In bathrooms or areas that may be slippery should be installed floor with a vinyl sheet coated with corundum chips which is easy to maintain.
- 2) Polished rubber floors with water emulsions provide better traction for wheelchairs than smooth stone tiles. Rubber flooring in the bathroom is a good choice for slip resistance. Which the wear-resistant rubber is slippery and friction And oil, acid and alkali.
- 3) Avoid wooden floors with shiny polyurethane surfaces that cause glare. Which has consequences for people using wheelchairs.

- 4) Non-slippery surfaces must have a coefficient of friction not less than 0.6 (0.8 for ramps), whether wet or dry. Rubber flooring often exceeds this threshold and is a good option.

9. Circulation in the Home Requirements

- 1) The clear opening width in front of the door should be at least 80 cm.
- 2) A 30 cm. nib is required beside the leading edge (latch side) of all doors at entrance level.
- 3) All of the internal doors have a clear opening width of at least 77.5 cm.
- 4) All hallways and corridors inside a dwelling should have a clear width of at least 105 cm.

10. Living / Dining / Kitchen



- 1) The minimum width of a room used as a living room is 320 cm at the narrowest point.
- 2) In the dining areas and living area should have space for turning a wheelchair and adequate circulation space for wheelchairs elsewhere.
- 3) A living room or kitchen-dining room should be at entrance level.
- 4) Living room window glazing should begin at 80 cm or lower and windows should be easy to open and operate.

11. Bedroom



- 1) Double and twin bedrooms have the same minimum floor area and both should have a minimum width of 300 cm.
- 2) The design should provide a reasonable route for a potential hoist from a main bedroom to the bathroom.

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