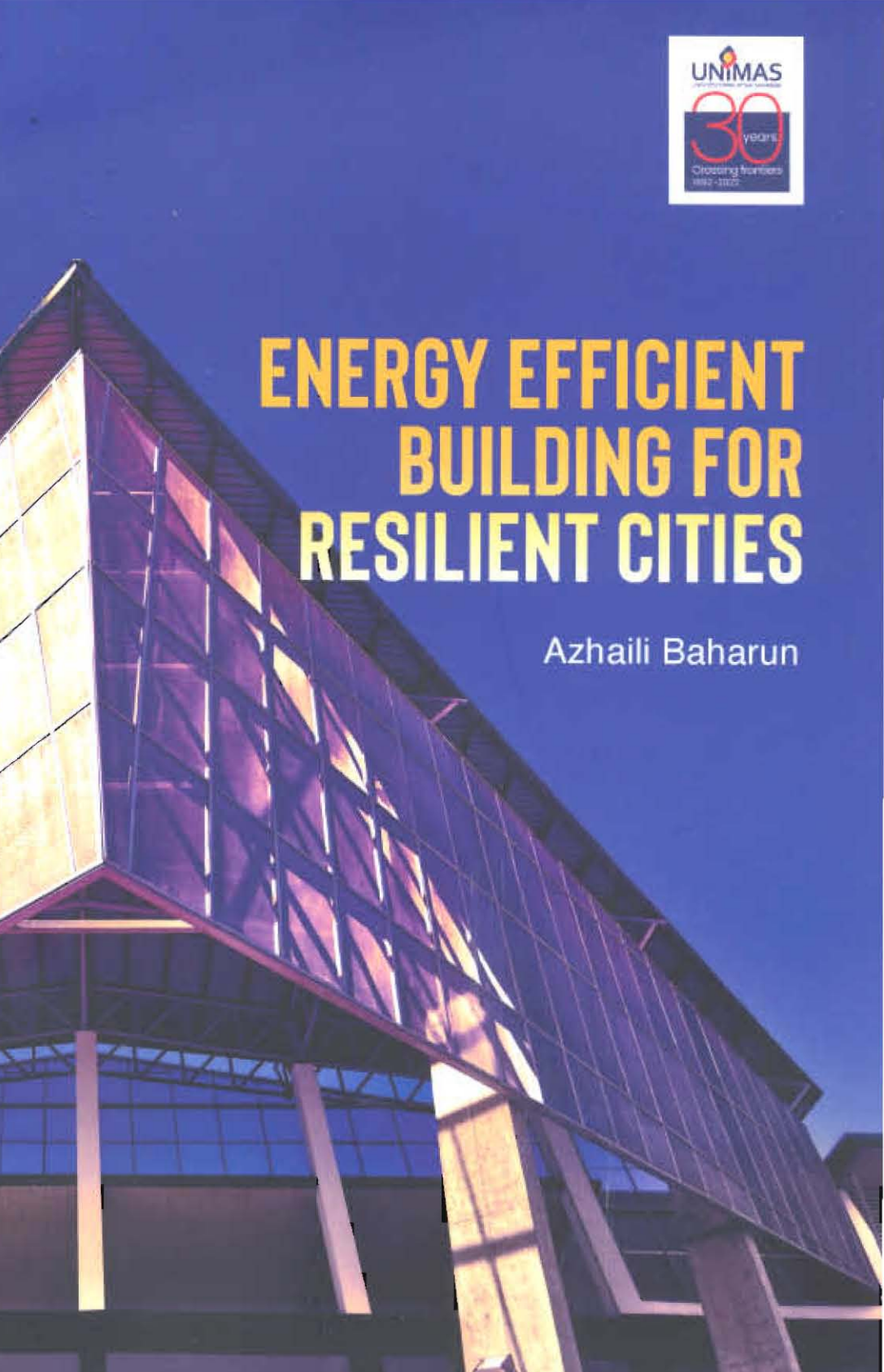

ENERGY EFFICIENT BUILDING FOR RESILIENT CITIES

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Preface

Climate change has a direct impact on the ecosystem, human health, and the global economy. For the past 30 years, developing countries in Southeast Asia, including Malaysia have witnessed the highest number of natural disasters with more than 90 percent related to climate disasters. In Malaysia, flood incidents have increased over the past 20 years with losses exceeding RM8 billion. In Kuala Lumpur, for example, studies show that the strength of thunderstorms and extreme rains have increased by 30 percent over the past three decades, causing floods to become more frequent. Due to the impact of climate change as well as other contributing factors such as natural resource management and development planning, disaster events will occur more frequently and on a larger scale.

The main purpose of this book is to introduce the energy-efficient building for resilient cities and why it is important for all parties including the private sector and government to prepare a future development plan that takes climate change factors into account. Introducing smart and greener cities in the future will be able to tackle future problems, especially climate change issues. In ensuring the resiliency and sustainability of a city, new or old, the city must be built green, and the buildings that comprise them have to be sustainable and green.

Acknowledgement

This book is written for my inaugural lecture on Energy and Building toward sustainable and resilient cities. The subject of the book is related to the climate action plans to reduce global warming.

After thanking Allah Almighty and my family for their support, I would like ro thank a few people here.

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Chapter 1

Energy and Environment

Introduction

Pressures on the energy supply and demand are not showing decrease in years to come. The energy division is blamable for three-quarters of the emissions that have already pushed global average temperatures higher since the pre-industrial age. The impacts are clearly visible in weather and climate extremes. The energy division then has to be at the core center of the solution to climate change.

The world is working towards achieving Goal 7, Affordable and Clean Energy, of the United Nation's Susrainable Developmenr Goals, with encouraging signs that energy is becoming more sustainable and widely available. Access to elecrriciry in poorer countries has begun to accelerate, energy efficiency conrinues ro improve, and renewable energy is rapidly becoming more popular in rhe electricity sector. Nevertheless, more focused attention is needed to improve access ro clean and safe fuels and technologies for three billion people, and to expand the use of renewable energy beyond the elecrriciry secror.

Hisrorically, energy is inseparable from the livelihoods and aspirations of a world population that is ser ro grow by some two billion people in 2050. The rising incomes keep pushing up demand for energy services. Many developing economies are experiencing an energy and emissions intensive period of urbanizarion and indusrrializarion. The energy sector is primarily

blamed and held responsible for climate change. With actions taken by the sector in handling climate change, still the direction of travel is a long way from alignment with the International Energy Agency (IEA)'s landmark of Net Zero Emissions by 2050 Scenario, which maps a narrow but achievable roadmap to stabilise the rising world temperatures and the achievement of other energy-related susrainable development goals.

Among different sectors in the energy division, the building sector consumes about 20% to 60% of the total energy in the different regions of the world with residential and commercial buildings are among the major consumers.

Global Warming

The global annual temperature has increased in total by a little more than 1°C since the Industrial Revolution. The Industrial Revolution is the rransition of manufacturing processes in Western countries and the United Srates, in the period from about 1760 to 1840. Between 1880 and 1980, the global temperature rose on average by 0.07°C every decade. Since the beginning of 1981, however, the rate of increase has become doubled. Over the last five decades, the global annual temperature has risen by 0.18°C per decade.

The Intergovernmental Panel on Climate Change (IPCC) in 2018 with 90 climate scientists from 40 countries concluded that global warming must be limited to 1.5°C by 2040 if we are to avoid the most devastating effects: extreme droughts, wildfires, floods, tropical storms, and other disasters that are referred to collectively as climate change. These effects are felt by all people but most severely by the underprivileged, low-income families, and farmers for whom climate change is often the main factor of poverty, displacemenr, hunger, and social unrest.

An IPCC Special Report on the impacts of global warming of 1.5°C (2019) further strongly recommended the world to reduce global carbon emissions by as much as 40% by 2030 to avoid global disasters.

Malaysia Action Plan and Strategies

Energy conservation has an impact on the way we globally and locally use energy and can affect climate change. The Malaysian government has adopted a policy to reduce its carbon footprint through more intensified energy efficiency measures in industrial, transport, commercial sectors and government buildings (Department of Environment, 2006).

Given this and the promise made by the 6th Prime Minister of Malaysia, in the United Nation Climate Change Conference (Copenhagen, 2009) to reduce carbon footprint or emissions by 40% by 2020 compared to 2005 levels, the energy efficiency initiative in Malaysia has become ever more crucial and critical. Malaysia has made green technology a mainstream ministerial portfolio in 2009 and followed by the launching of the National Green Technology Policy 2009 by Ministry of Energy, Green Technology and Water (KeTTHA), later known as Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) in 2018.

Later, the National Energy Efficiency Action Plan 2016-2025 was initiated to encourage the adoption of energy efficiency in the public and private sectors through reducing electricity demand growth by 8% over the 10-year period with a total reduction of greenhouse gas (GHG) emissions of 38 million tonnes of carbon dioxide equivalent.

Along this line, Malaysia also has been promoting the use of renewable energy and adoption of energy efficiency in sustainable development including granting attractive incentives. The policy also includes more Foreign Direct Investment (FDIs) and Domestic Direct Investment (DDIs) and expansion of Green Technology research, development, innovation and commercialization (RDIC) activities by local research and higher learning institutions.

Data gathered has shown that the residential and commercial building sector is one of the major energy consumption sectors that consumed a large amount of the country's total energy annually (Siri Birkha Mohd et al., 2021). Prior to this, the energy conservation and energy in building sector has been subjected to further improvement and development. For the long term (in the 11th and 12th Malaysia Plan) Research Development Innovation and Commercialization (RDIC) on green technology has been given importance under the policy to move forward to satisfy criteria such

as low greenhouse gas (GHG) emission, conserving the use of energy and natural resources as well as promoting the use of renewable resources.

Sarawak Action Plan

Sarawak's Post COVID-19 Development Straregy 2030 (PCDS 2030), launched in July 2022, has been developed specifically to ensure a clean and healthy environment for all by having policies on sustainable forest management as well as adopring of new technologies and innovations to support Malaysia's commitmenr ro reduce GHG emissions intensity of GDP by 45% in 2030 and to support Malaysia's commitment to keeping 50% of the country under forest cover.

The blueprint prioririzes biodiversity conservation and natural resources managemenr, climare change mitigation, and adapration while enabling the creation of an environment with modern infrastructure in line with the country's Industrial Revolurion 4.0 drive. Prior to the PCDS commitment, Sarawak has moved forward by identifying 38 smart city initiatives in five focus areas of economic growth, smart living, clean environment, digital government and digital infrastructure. The initiatives were implemented beginning in the year of 2021. The Kuching Smart City Master Plan is the first to be developed with low carbon mobility, resilient, sustainable, and smart city infrastructure initiatives to be replicated in other towns of Sarawak. These initiative directly support the action plan of United Nation's and Malaysia Strategic Acrion Plan in handling global warming.

Chapter 2

Urbanization and Climate Change

Over the last couple of decades, urban areas around the world have been engaged in a multitude of initiatives aimed at creating better environmental, social, and economic conditions, and enhancing their attractiveness. These efforts have been numerously labeled by planners and policy makers: from 'sustainable city' to 'eco city', from 'low carbon city' to 'resilient city', and from 'liveable city' to 'smart city'. Often, these concepts appear to be interchangeable. Nevertheless, cities are increasingly vulnerable to natural or artificial disasters due to large populations, numerous buildings, and complicated social networks.

The United Nations (UN) predicts that by 2050 around 68% of humanity will live in cities. Although cities represent only 3% of the planet's surface, they consume 78% of energy and produce 60% of greenhouse gas emissions. For this reason, in 2016 the UN itself released the New Urban Agenda to advise countries on their urbanization processes with the goal of making cities more habitable, inclusive, healthy, resilient, and sustainable.

Resilient City

Making Cities Resilient was introduced by United Nations International Strategy for Disaster Reduction (UNISDR) in 2010. The campaign aims to "*promote awareness and commitment for sustainable development practices that will reduce disaster risk and increase the wellbeing and safety of citizens – 'to invest today for a better tomorrow'*" (UNISDR, 2010).

Five years before UNISDR 2010, Vale and Campanella (2005) had already described the resilience cities as the symbolic dimensions of disaster and recovery, and the politics of reconstruction. They argue that, to understand urban resilience is to understand the ways in which human narratives are constructed to interpret the meanings of urban reconstruction.

Newman, Beatley, and Boyet (2009) focus on only one dimension of resilience for Resilient Cities: the oil crisis. In this context, they point out that "*a danger that few think about with such immediacy is the threat of the collapse of our metropolitan regions in the face of resource depletion – namely, the reduction in the availability of oil and necessary reduction in all fossil fuel use to reduce human impact on climate change*". Their focus was less on urban resilience and more on "*the challenges posed to metropolitan areas in the face of responding to their increased carbon footprint, dependence on fossil fuels, and impact on the irreplaceable natural resources*"

Many city governments perceive building urban resilience as a positive, flexible approach to manage complex, interconnected and unpredictable threats such as extreme weather, shifting climate, ageing infrastructure, economic instability and equity concerns (Woodruff et al., 2018). Funding from leaders, philanthropic organisations and finance agencies has grown over the past decade, encouraging cities increasingly to engage in resilience work. On the other hand, scholars often present urban resilience as an innovative approach to or framework for connecting and managing a wide range of different urban shocks and long-term stresses (Ahern, 2011), (Wardekker et al., 2010). Resilience efforts undoubtedly build on prior urban sustainability or climate change adaptation explicitly aiming to 'transform fundamental public institutions, functions, and operations in city government' (Marrín & McTarnaghan, 2018; Harris et al., 2018).

Low-Carbon Smart City towards Resilient City

Earth is very susceptible to climate change, and exposure to climate-driven natural disasters will increase. By 2050, almost 70% of the total world population is expected to be living in towns and cities, and climate resilience planning will become increasingly critical. The emergence of a smart climate approach bringing together eco-city, sustainable city, and conventional low-carbon green city approaches into the climate resilient and low-carbon

smart city development will generate a much higher value with lower cost implication.

When studying cities, to understand the term sustainability, one must take into account the meaning of sustainable urban development. This is a process of change in which resource exploitation, investment direction, technological development and institutional change are consistent with present and future needs. The term "sustainable city" became popular in the 1990s (Roy 2009), signifying the relationship between economic, social and environmental sustainability aspects (Ahvenniemi et al., 2017).

The concept of smart city on the other hand is a relatively new and perceived as the same as information city, digital city and sustainable city (Yigitcanlar, 2006). After 2013, it has been frequently used exceeding other terms including sustainable city (Jong et al., 2015; Yigitcanlar, 2016). Although a number of authors have difficulties in placing the concept together, these definitions are not contradictory but partially overlapping (Scheel & Rivera, 2013; Cocchia, 2014). In general, however, it is understood that smart cities make use of information and communication technology extensively to help cities build their competitive advantages (Yigitcanlar & Baum, 2008; Caragliu et al., 2011). Smart cities can be seen as a conceptual model where urban development is achieved through the use of human, collective and technological capital (Angelidou, 2014).

Caragliu et al. (2011) conceptualise smart city using the following five main characteristics: an enhanced administrative and economic efficiency that enables the development of culture and society by utilising networked infrastructures; an underlying emphasis on business oriented urban development; a strong focus on the goal of realising the social inclusion of different kinds of urban residents in public services; an emphasis on the significant role of high-tech and creative industries in long-term growth, paying close attention to the function of social and relational capital in city development, and; a vision to rake social and environmental sustainability as an important aspect of smart city development. Other authors also point to the necessary ingredients for the composition of a smart city, such as: smart economy, smart mobility, smart environment, smart people, smart living and smart governance (Lazaroiu & Roscia, 2012; Lee et al., 2014; Jong et al., 2015). Jong et al. (2015) concluded that, the concept of smart city goes beyond the definitions of information cities, digital cities, and intelligent

cities, because it contextualises technology to be used in favour of systems and services for people.

The evaluation of a smart city, as discussed by Marsal-Llacuna et al. (2016) should consider past experiences of environmentally friendly and liveable cities, encompassing sustainability and quality of life, in addition, of course, to the composition of technological factors. Lazaroiu and Roscia (2012) state that it should represent a technological community that is interconnected, sustainable, comfortable, attractive, and secure. Smart cities make use of city data for traffic management, energy consumption statistics, security, and optimising the operation of municipal services (Harrison et al., 2010) and encourage the increase of new suppliers to the smart city market niche, using technological resources for the management of urban services (Carvalho & Campos, 2013; Angelidou, 2015).

The term smart city is, therefore, a concept that contains a number of sub-themes such as smart urbanism, smart economy, sustainable and smart environment, smart technology, smart energy, smart mobility, smart health, and more (Gudes et al., 2010; Cocchia, 2014; Lara et al., 2016).

According to Dhingra and Chattopadhyay (2016), a smart and sustainable city has goals to be achieved in an adaptable, reliable, scalable, accessible, and resilient way, such as: improving the quality of life of its citizens; ensuring economic growth with better employment opportunities; Improving the well-being of its citizens by ensuring access to social and community services; establishing an environmentally responsible and sustainable approach to development; ensuring efficient service delivery of basic services and infrastructures such as public transportation, water supply and drainage, telecommunication and other utilities; ability to address climate change and environmental issues, and; providing an effective regulatory and local governance mechanism ensuring equitable policies.

A sustainable city specifically aims to achieve the balance between the three values, i.e. the economy, the environment and impacts on society. Cities have to find the optimal balance point based on the general indicators of sustainable development, a sample list of which is presented in Table 2.1.

Table 2.1 Sustainable Development Indicators and Leading Indicators

Sustainable Development Indicators (thematic area)	Leading indicators
Socio-economic Development	GDP Growth per Capita
Climate Change	Greenhouse Gas Emissions Consumption of Energy from Renewable Sources
Sustainable Transport	Energy Consumption in the Transport Sector in Relation to GDP
Sustainable Consumption and Production	Efficiency of Resources
Natural Resources	Occurrence of Birds' Common Protection of Fish Stocks
Public Health	The Average Life Expectancy in Good Health
Social Inclusion	Risk of Poverty
Demographic Changes	Employment Rate of Older People
Global Partnership	Official Development Assistance
Good Governance	(no leading indicator)

Source: L. Jodkowska, Stopień realizacji celów zrównoważonego rozwoju i zrównoważonego społeczeństwa na wybranych przykładach, (in:) Trendy i wyzwania zrównoważonego rozwoju, Zapol, Szczecin 2001.

When it comes to the environmental issues of smart cities, the discussion is more political in nature, considering international resolutions and innovative solutions to combat complex urban challenges. According to Dhingra and Chattopadhyay (2016), there are four attributes of smart and sustainable cities: sustainability; quality of life; urban aspects, and; intelligence. The findings supported Carrillo et al. (2014) and Kondepudi (2014) statement of other four main themes: society; economy; environment, and; governance. These themes are also presented by Yigitcanlar and Velibeyoglu (2008) and Yigitcanlar and Lönnqvist (2013) in their works on concept that relate to the development of smart cities. A similar concept, smart-eco city, proposes that

the city should be ecologically healthy, use advanced technologies and have economically productive and environmentally efficient industries, have a responsible and harmonious systematic culture, and have a physically aesthetic and functionally living landscape (Yigitcanlar & Lee, 2014).

The effect of urbanisation, increase numbers of buildings, population density growth and activity contributed to another problem, Urban Heat Island (UHI) phenomena. The increase in urban temperature provokes an average increase of cooling energy loads. The use of air-conditioning systems in housing increases due to climate change, becoming the major share of the total energy consumption in hot climates, which are greatly impact CO2 emissions (Baharun A et al., 2018). The use of air-conditioning systems comes with emission of waste heat inro the atmosphere, contributing to rhe increase in urban temperature, and giving rise to a dangerous vicious circle. Minimizing the temperature increment can be achieved by areas suitable for heat sink (Baharun A et al., 2016). The temperature profile of Urban Heat Island (Figure 2.1) shows that the peak temperature is at the centre of a city and diminishes down in the rural areas.

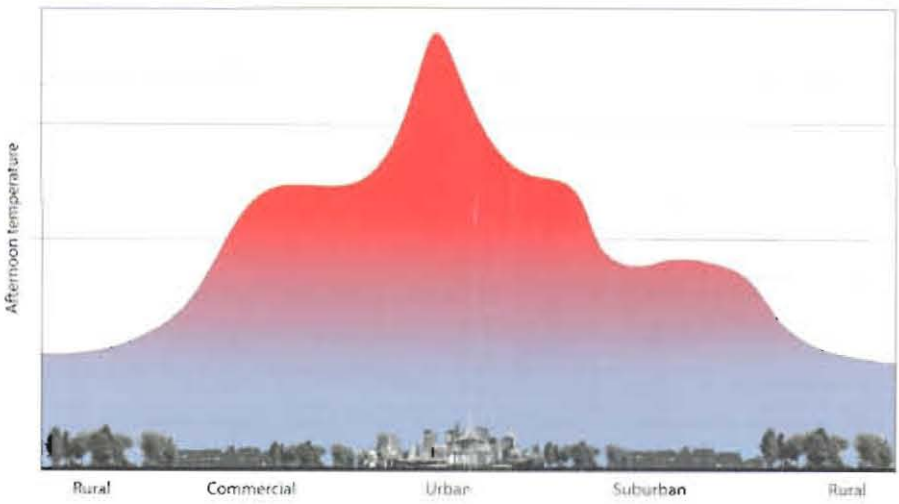

Figure 2.1 Urban Heat Island Profile

The energy impact of the UHI effect is also detrimental in colder climates despite the energy saving achievable on the heating demand. The cooling demand increase determined by the UHI intensity is more important than the heating demand decrease. Cooling demands also increase with the global climate change and the increase in the frequency of extreme weather events such as heatwaves. This consideration makes the topic of UHI very important in the field of energy and environmental studies for a sustainable city.