How to drive Thailand Developers Toward Net Zero:
Lessons Learned from the Developer's Perspective and the Global Studies

by

Ravisara Lertpunyaroj

Bachelor of Science in Business Administration
Indiana University, Kelley School of Business, 2015

SUBMITTED TO THE PROGRAM IN REAL ESTATE DEVELOPMENT IN CONJUNCTION WITH THE CENTER FOR REAL ESTATE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE IN REAL ESTATE DEVELOPMENT
AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

FEBRUARY 2023

Signature of Author:_____
Ravisara Lertpunyaroj
MIT Center for Real Estate
January 13, 2023

Certified by:_____
Zhengzhen Tan
Lecturer, Research Scientist, Center for Real Estate
Thesis Supervisor

Accepted by:_____
Professor Siqi Zheng
STL Champion Professor of Urban and Real Estate Sustainability
MIT Center for Real Estate + Department of Urban Studies and Planning
Faculty Director, MIT Center for Real Estate (CRE)
Director, MIT Sustainable Urbanization Lab

How to drive Thailand developers toward net zero:
Lessons learned from the developer's perspective and the global studies

by

Ravisara Lertpunyaroj

Submitted to the Program in Real Estate Development in Conjunction with the Center for Real Estate on January 13, 2023 in Partial Fulfillment of the Requirements for the Degree of Master of Science in Real Estate Development at the Massachusetts Institute of Technology

ABSTRACT

In recent years, there has been a growing concern regarding climate change risks to real estate in developed and developing countries. Climate change refers to long-term shifts in temperatures and weather patterns. Since the 1800s, human activities have been the key driver of climate change due to burning fossil fuels such as coal, oil, and gas, which generate greenhouse gas emissions that trap the sun's heat and raise temperatures. Climate change disrupts national economies and affects lives globally. Thailand is one of the most vulnerable countries in the world that has been affected by changes in weather patterns and natural disasters. It was ranked as one of the ten most flood-affected countries in the world. The extreme weather could impact 2 million lives by 2035- 2044 (Tan & Zheng, 2022). Keeping global warming below 1.5 °C is a challenging task. The Paris Agreement aims at achieving net zero carbon dioxide (CO2) emissions in the second half of this century, and Thailand is one of many countries that have committed to this goal. At the press conference, Prime Minister Prayut Chan-ocha announced that the country is committed to net zero emissions by 2065. However, net zero development in Thailand is new, and there is not much information about net zero practice in the region. There is no study about the adoption of net zero in the real estate sector. This qualitative study analyzes the reasons developers adopt net zero and how the public sector can help developers achieve net zero goals based on developers' perspectives. The rationale for conducting this research is to bring Thai voices into the global real estate sector's net zero transition conversation. From the research, I found that competitive advantage, branding and marketing, and lower green technology costs are the key elements that influence Thai real estate developers to adopt the net zero practice. However, the developers need support from the government, including technological advancement, government incentives, and guidelines. The finding and discussion can help the developers adopt necessary responses to reduce negative impacts, and the policymakers can learn from the recommendations for the appropriate policies for the real estate sector.

Keywords: net zero; real estate development; developer; decarbonization; pathway to reduce greenhouse gas; Thailand; commercial; residential

Thesis Supervisor: Zhengzhen Tan
Title: Lecturer, Research Scientist, Center for Real Estate

ACKNOWLEDGEMENTS

Zhengzhen Tan,
I could not have undertaken this journey without you. Thank you for your invaluable feedback throughout the process. I'm so grateful to have you as my thesis advisor.

Kairos Shen, Siqi Zheng, and CRE Faculty
Thank you for your generosity and always being there to support me from the beginning till the end.

MSRED Cohort of 2022
Thank you for your moral support. It has been an amazing 18 months. Can't wait to meet you again.

Suwan, Saranthip, Benz, and Princess Lertpunyaroj
I am here today because of you. I love and miss you all.

TABLE OF CONTENT **Page**

1. Introduction……..…….. 5
    a. Thailand's History of climate change Policies…….… 6
    b. Impacts of climate change on the Thai real estate sector……..…..... 7
    c. National Committee on Climate Change Committee (NCCC)……..…… 7
    d. Energy in Residential and Commercial Sectors……..…... 8
    e. Thailand's Building Energy Code (BEC)……..… 10
    f. Zero Energy Building…….…….…... 10
2. Literature Review: Global net zero adoption……..…….…….. 11
3. Statement of the Problem…….…….…….. 13
4. Methodology…….…….…… 14
5. Finding…….…….. 16
    a. The perspective of developers toward net zero by 2065……..……... 16
    b. What drives real estate developers to adopt net zero practice in Thailand?..... 17
    c. How can the Thai government help real estate developers achieve net zero?.....19
6. Global Case Studies……..……..… 22
    a. California…….…….. 22
    b. Amsterdam…… 24
    c. Singapore…….……..…… 26
7. Conclusion, Limitation & Outlook …….……..…..…… 28

Appendix

8. Glossary…….……. 32
9. Table of Figures & Table…….33
10. Bibliography……..…. 34

1. INTRODUCTION

Climate is the average weather in a place over many years. However, the rapid climate changes are caused by humans using oil, gas, and coal for our homes, factories, and transportation. When these fossil fuels burn, they release greenhouse gasses - primarily carbon dioxide (CO2) and methane (Butler, 2016; Howarth, 2014). These gasses trap the sun's heat and cause our planet's temperature to rise (Riebeek, 2011). The world is now about 1.1°C warmer than it was in the 19th century - and the amount of CO2 in the atmosphere has risen by 50 percent (Kaufman, 2020; Houghton, 1989). Such a temperature rise impacts several aspects, such as intense droughts, severe fires, rising sea levels, flooding, and catastrophic storms (DeFries et al., 2019; Gulzar, 2021). A 2018 UN report said that limiting global temperature rise to no more than 1.5°C could have helped prevent the worst climate impacts and maintain a livable climate for humans (Rhodes, 2019). But without taking action, global warming is projected to reach 2.7°C by the end of the century (Le Page, 2021). The UN Secretary-General António Guterres said this climate emergency was nothing less than a code red for humanity (Higham, 2021; Scott, 2021). Thus, keeping global warming below 1.5 °C is a top priority for many governments. This could be our last chance to put the world on track to limiting warming to below 2.0°C above pre-industrial levels (Liu, 2019).

In 2020, Thailand's carbon emission was 3.68 t CO2/capita/yr (Energy Policy and Planning Office, 2022). Its emission is lower than the global rate of 4.8 tons (Ritchie, 2020). Thailand is highly vulnerable to climate change impacts. According to the 2020 Nationally Determined Contribution (NDC) report, the country is ranked 13th in the "extreme risk" category that is most vulnerable to future climate change (Veng, 2020). Thailand is also among the top 10 countries at high risk of long-term climate change (Hanson, 2011; Marks, 2011). Floods are Thailand's most significant natural hazard in terms of economic and human impacts (Samphantharak, 2014). The rising temperatures in Thailand increase evaporation, leading to a shorter rainy season and, therefore, more frequent and intense droughts (Nock, 2011). In addition, Bangkok is highly vulnerable to rising sea levels (Tebakari, 2020). Bangkok is a coastal city with a population of 8.2 million people (Dhakal & Shrestha, 2016). World Health Organization (WHO) predicted that if this should ever happen, the number of people affected by an extreme river flood could grow by over 2 million by 2035–2044, and coastal flooding could involve a further 2.4 million people by 2070–2100 in Thailand (World Health Organization, 2015). If the government mismanages the climate change policies, by 2050, the entire city could be underwater (Boyle, 2019).

The rising seas and sinking land force the country to adopt carbon neutrality and net zero policies. In the Paris Agreement of 2015, Prime Minister, Prayut Chan-o-cha, announced that Thailand is committed to

reaching carbon neutrality by 2050 and net zero by 2065 (Diewvilai, 2022). The announcement implies that Thailand is devoted to reducing greenhouse gas (GHG) emissions by approximately 40 percent by 2030 and 80 to 95 percent by 2050 (Cline, 2011).

To achieve the low carbon emission target, Thailand's Ministry of Energy has developed a 20-year Energy Efficiency Plan, which requires new buildings to be zero consumption by 2030 (Misila, 2020). The concept of net-zero energy buildings is to reduce energy consumption and provide enough energy generation equal to that use. Passive and active design strategies can reduce the building's energy usage. In Thailand, several studies have been conducted on designing energy-efficiency buildings. However, few studies have developed designs for achieving a net-zero energy building. Those studies focused on small houses and small government and academic buildings (total floor area less than 10,000 sq. m.) In addition, there are currently no mandatory carbon targets, actions, or schemes imposed.

Thailand's History of climate change Policies

Kyoto Protocol and Paris Agreement

Since 1992, when the United Nations recognized climate change as a serious issue, negotiations among countries have produced notable accords, including the Kyoto Protocol and Paris Agreement. Thailand signed the Kyoto Protocol in February 1999 and ratified it in August 2002. In April 2016, Thailand signed the Paris Agreement and ratified it five months after the signing date (United Nations Climate Change, (n.d.).

The Kyoto Protocol is the first legally binding agreement under which industrialized countries will reduce their collective emissions of greenhouse gasses by 5.2 percent compared to the year 1990. The Paris Agreement set out to improve upon and replace the Kyoto Protocol. It requires nearly all developed and developing countries to set emissions reduction goals. All member parties agree to limit global temperature to rise no more than 1.5 °C. It also mandated a progress review every five years with a development fund of $100 billion by 2020, replenished annually, to help developing countries adopt non-greenhouse-gas-producing technologies (Seo, 2017).

In the lead-up to the Paris meeting, the UN tasked governments to submit plans detailing how they intended to reduce greenhouse gas emissions. Those plans were technically referred to as intended nationally determined contributions (INDCs). By December 2015, 185 countries, including Thailand, had submitted

measures to limit or reduce their greenhouse gas emissions by 2025 or 2030. However, governments can choose their targets, and there are no enforcement mechanisms to ensure they meet them.

COP26 (2021)

The final agreement, the Glasgow Climate Pact, calls for member countries to reduce coal use and fossil fuel subsidies and urges governments to submit more ambitious emissions-reduction targets by the end of 2022. During this meeting, Prime Minister Prayut Chan-o-cha announced Thailand's aim to reach carbon neutrality by 2050 and net zero greenhouse gas emissions by 2065, as Thailand is one of the top ten countries in the world most affected by climate change.

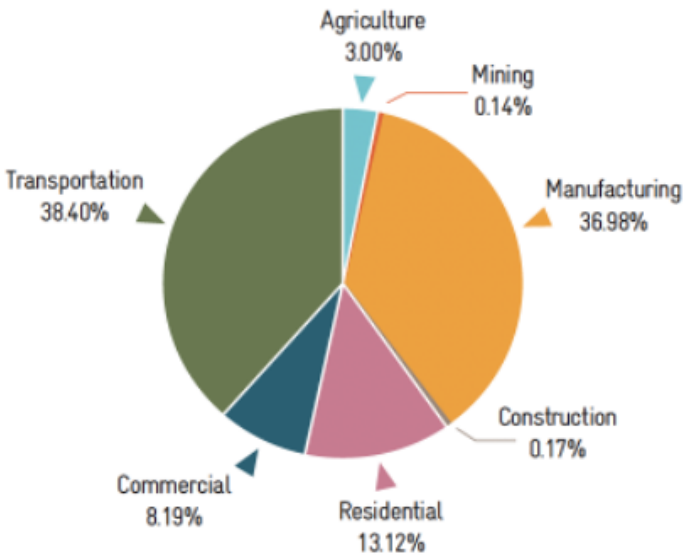
Impacts of climate change on the Thai real estate sector

Thailand is vulnerable to exposure to natural hazards, including heavy rainfall, floods, heat waves, droughts, and rising sea levels along the coasts. It is ranked 81st out of 191 countries by the 2019 Inform Risk Index (World Bank Group, 2021). Thailand is ranked one of the most flood-prone countries in the world, including riverine flash and coastal flooding. Flooding contributes to almost 50% of the natural hazards occurred in Thailand (Munpa, 2022). World Bank projected that the extreme river flood could impact 2 million people by 2035-2044, and coastal flooding could impact a further 2.4 million people by 2070-2100. According to UNISDR, the average loss from flooding in Thailand is close to $2.6 billion per year (World Bank). Without planning and mitigation, the real estate sector will be directly affected. Several studies indicated that the chronic events of flooding discount the property value (Sawangnate, 2022). In addition, future increases in flood risk disproportionately impact lower-income neighborhoods because the locations are in cheaper areas with high flood risk (Chongwilaikasaem & Chalermyanont, 2022).

National Committee on Climate Change Committee (NCCC)

National Committee on Climate Change Committee (NCCC) is responsible for Thailand's climate change policies, strategies, and planning, as well as international cooperation and funding. Long-Term Low Greenhouse Gas Emission Development Strategy (LT-LEDS 2022) is a blueprint for Thailand to achieve carbon neutrality and net zero emissions targets while balancing economic growth and social welfare (Ministry of Natural Resources and Environment, 2022)

Figure 1: Share of final energy consumption by economic sector, 2020



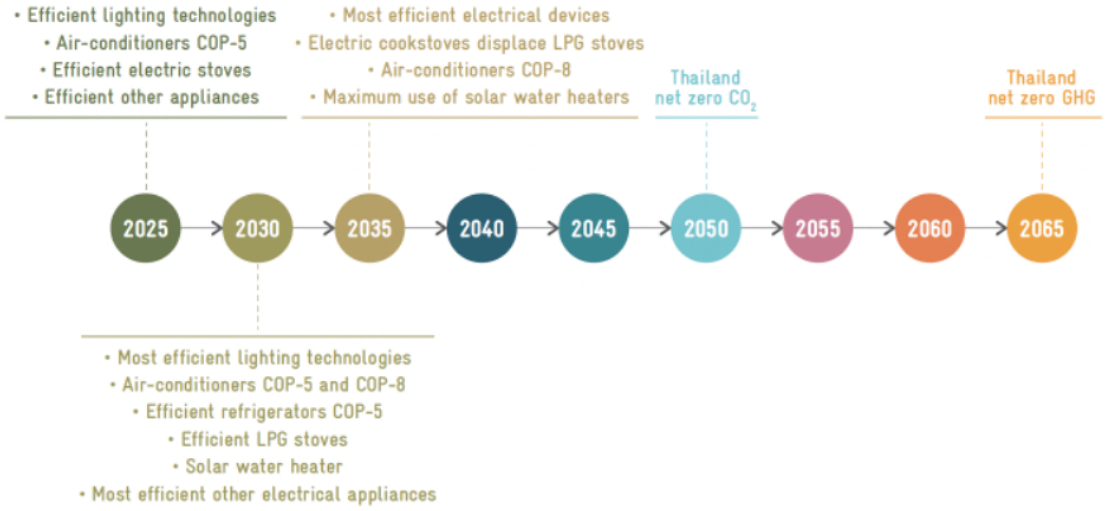
Source: Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy (Revised version), Ministry of Natural Resource and environment

Energy in Residential and Commercial Sectors

According to the Ministry of Natural Resources and Environment (2020), the building sector contributed 21.3% of the operational energy consumption, 13.1%in the residential, and 8.2% in the commercial sector. The Ministry of Energy updated the Energy Efficiency Plan (EEP2015) and Renewable energy Plan (AEDP2015) to align with Thailand's climate change master plan, which targets the country to be a low-carbon society in 2050. The EEP2015 aim to reduce 30% of the country's energy intensity and the buildings sector's energy intensity by 12% by 2036 compared to 2010. The AEDP2015 plans to increase the percentage of renewable energy up to 30% in the grid by 2036 (Ananwattanaporn et al., 2021).

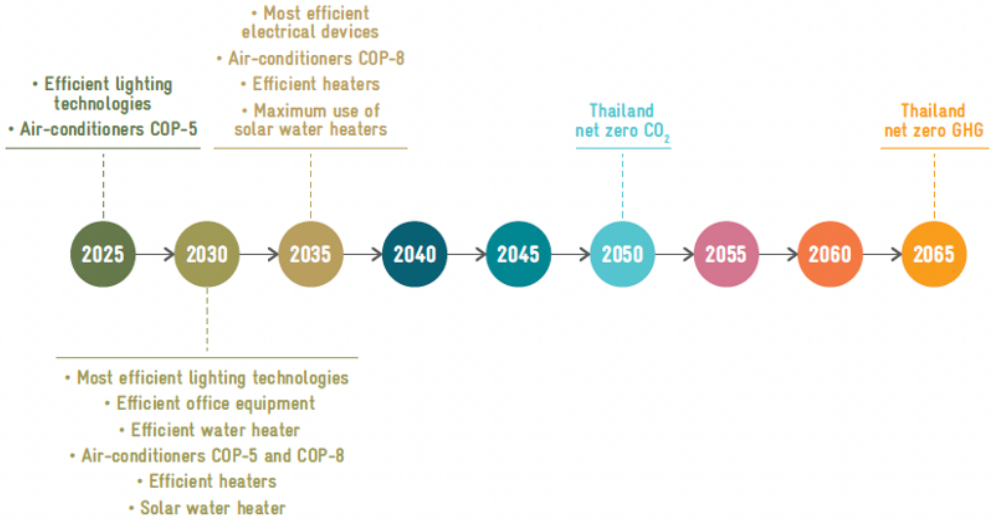
Electricity and LPG (Liquefied Petroleum Gas) are Thailand's primary energy sources for commercial and residential sectors. Biomass is also used in the residential sector. LT-LEDS provides similar mitigation actions for these sectors. It lays out the timeline to improve energy efficiency technologies, including air-conditioners, refrigeration, electrical appliances, and lighting technology, adapt solar water heaters, and displace LPG stoves with the electric stove (Ministry of Natural Resources and Environment, 2022).

Figure 2: LT-LEDS's net zero emission timeline for the residential sector



Source: Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy (Revised version), Ministry of Natural Resource and environment

Figure 3: LT-LEDS's Net zero timeline for the commercial building sector



Source: Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy (Revised version), Ministry of Natural Resource and environment

Thailand's Building Energy Code (BEC)

Building Energy Code (BEC) is applied to buildings with a gross floor area (GFA) of more than 10,000 sq. m. However, the authority will tighten the regulation to enforce buildings with a GFA of more than 5,000 sq. m. In 2021 and 2,000 sq. m. in 2023 onward. The code evaluates the compliance of six aspects, including the building envelope, lighting system, air conditioning system, water heating system, renewable energy system, and total energy consumption.

Zero Energy Building

ZEB defines a building that can produce renewable energy off-grid equivalent to the total energy consumption. The design of the building required to reduce the energy consumption as much as possible through the higher energy efficiency building envelope, air-conditioning and ventilation system, lighting systems, and other building equipment to be balanced with renewable energy generation (Peterson. et al., 2015).

From many studies, ZEB is possible in Thailand for newly constructed and retrofitted existing buildings. The cost-benefit of investment in ZEB office projects proved internal rate of returns (IRRs) ranging from 10.73% to 13.85% with payback periods of 7.2 to 8.5 years from the passive and energy efficiency designs (Lohwanitchai & Jareemit, 2021). Retrofitted residential buildings proved to have an IRR of 19.23% with a payback period of 4.36 years from energy saving (Lohwanitchai, K & Jareemit, 2021).

While sustainability, in general, has been discussed in many studies, sustainability in real estate is still lacking behind, and limited studies about net zero. Most of the studies in Thailand evaluate and access zero energy building (ZEB). However, there is a knowledge gap and a lack of guidance for achieving net zero for the real estate industry.

2. LITERATURE REVIEW

The concept of net zero is relatively new. Currently, there is no adoption research on net zero in Thailand. I will summarize the literature on critical factors driving the real estate sector to adopt net zero North America and European Union (EU).

Global Net Zero Adoption

The real estate sector represents nearly 40% of greenhouse gas emissions, and approximately 11% of the emissions come from building materials (IEA, 2019). Climate risk exposes the real estate sector to transition and physical risks. Transition risks are associated with the shift to net zero, including government regulation, an adjustment in consumer behavior, the economy, and other human responses to climate change. The impact of transition risk in commercial and residential assets corresponds to the assets' carbon intensity and the costs related to meeting the carbon reduction target (Swartz et al., 2022). Physical risks are the direct and indirect risks associated with the damage of assets from acute and chronic events from climate change (Boland et al., 2022). The events may increase insurance premiums, operational costs, and maintenance costs, as well as reduce asset value (Carpenter et al., 2022). The combination of transition and physical risks creates a sense of urgency for the real estate sector. Therefore, there is increasing pressure from stakeholders across the value chain in North America and the EU, including investors, government, occupiers, and communities that drive developers to adopt net zero (Carpenter et al., 2022).

ESG has recently been moved to a higher priority for real estate investors to mitigate risk and create long-term financing opportunities in North America and the EU. The contribution of the transition and physical risks made the potential of mispricing real estate. North American bank reported that many real-estate portfolios are exposed to physical and transition risks and are likely to be de-valuated. Without any mitigation plan, climate risks may reduce the annual return by up to 40% within the next ten years (Boland et al., 2022). A survey conducted by UNEP FI and CRREM reported that 68% of financial institutions in the EU would incorporate climate risks in their strategic decisions in real estate holdings. They identified crucial drivers, including stricter regulatory frameworks for energy efficiency and GHG emissions, the rising threat of properties being economically obsolete, anticipated rises in the cost of energy and carbon, and increasing reporting obligations (Wein et al., 2022). Institutional investors emphasize on balance ESG-related goals with other attributes, such as financial performance. The market is shifting towards renewable energies, more energy-efficient buildings, and stricter ESG requirements. Some investors will not consider buying assets that do not meet specific minimal criteria, which regulation may soon catch up to enforce these requirements. In addition, long-term Institutional investors seek to invest in assets with high ESG

standards because they are hesitant to allocate time and resources to improve such assets to meet the future standard (Davies, 2022).

Governments and regulators significantly motivate the real estate sector toward net zero with sticks and carrots in North America and the EU. At the 2021 UN Climate Summit (COP26),136 nations joined forces to commit to achieving net zero. The commitment alarms the policymakers to devise an action plan and policies to reach the national goal. Policymakers use "sticks" (mandates) and "carrots" (incentives) to achieve the goal. Examples of sticks are building performance standards, penalties, and mandatory green certificates, while the measure of carrots are tax credits/rebates, subsidies, and zoning incentives (Tan & Zheng, 2022). The sticks and carrots can be applied at the national and the localities level. Financial regulators also put high pressure on real estate sectors. European companies are required to comply with the regulations to disclose carbon reporting and climate risk reporting. Financial Stability Oversight Council reported that the United States is expected to comply with more regulatory actions and disclosure for the Banks (ULI Global Sustainability Outlook 2022, 2022). Task Force on Climate-Related Financial Disclosures (TCFD), a new international climate risks reporting, is required for all fund managers in the United Kingdom to adopt from 2025 (Tan & Zheng, 2022). Many more countries will likely face similar requirements (ULI Global Sustainability Outlook 2022, 2022). These factors push and pull the real estate sector, including the developers and asset owners, to achieve net zero.

There is a shift in the occupiers' demand for greener and more sustainable spaces, especially in commercial real estate. Jones Lang LaSalle's (JLL) global survey reported that the Covid-19 pandemic accelerated the call for environmental and social responsibility. Tenants are setting net zero goals for 2030 or earlier, which is faster than their national policies. For tenants to achieve their sustainability strategies, they demand space that is energy efficient and align with their goals. Employees' health and well-being (53%) and brand reputation (51%) drive European corporate strategies. In North America (60%) and Asia Pacific (59%), meeting society's expectations is the key mover for tenants. In addition, 42% of the global occupiers believe that their employees will soon demand green and sustainable workspace (Puybaraud et al., 2021). Even though the incentives for the occupiers are different across the continents, the result will push the real estate sector toward net zero. Green premium is another factor that allows developers and building owners to benefit from higher rent and asset value. Forty-two studies from Dalton and Fuerst in 2018 illustrated that green certifications yielded a 6% rent premium and a 7.6% sales premium (Ulbrich, 2022). As sustainable spaces are becoming more important for tenants, it is a defensive action for asset developers and owners to preserve the building value and mitigate risk.

There is also increasing community awareness about the benefits of a sustainable built environment. Thus, it incentivizes North America and the EU's real estate sector to support the city to decarbonize. Real estate owners can use their location to generate and store energy, helping stabilize energy grids and reduce renewable energy costs. Real estate players can introduce new revenue streams, such as EV charging stations and green property management. Developers can explore green materials that lower carbon embodied and lower cost, such as green steel, tall timber, modular constructions, and other new technologies and materials to reduce carbon embodied (Boland et al., 2022). Carbon emissions reduction in the city, including emissions from the building, have proved to have a significant improvement in air quality, a decrease in chronic disease, and better health for people in the community (Ulbrich, 2022). Therefore, decarbonization in the real estate sector will generate many positive impacts on the neighborhood.

3. STATEMENT OF THE PROBLEM

Thailand sets a national goal to achieve net zero by or before 2065. Although the country has not yet mandated a net zero policy, the Thai government has set out its approach to tackling climate change in plans on energy efficiency, alternative energy development, power development, and waste management. What is unclear is the action plan and pathway to achieve the national goal for the real estate industry.

At this point, many developers set a goal aligning with the national plan to reduce carbon emissions to tackle climate change. What is less clear is the explanation of why the majority of developers choose to follow the government policy since there are no laws to enforce their actions. Studies focusing on Thai developers' decisions to adopt a net zero are limited, so it is imperative to conduct this research study. This research can help Thailand policymakers to form an appropriate policy based on the developers' perspectives.

Research Question and Hypothesis:

Main Questions:

- What drives real estate developers to adopt net zero practice in Thailand?
- How can the Thai government help real estate developers achieve carbon neutrality and net zero?

Hypothesis:

I hypothesize that the factors that drive developers to achieve net zero may align with the global key drivers, including the demands from investors, policies and regulations, and the community. To accelerate net-zero adoption, Thailand policymakers and regulators must develop effective sticks and carrots targeting the real estate development sector to motivate developers.

4. METHODOLOGY

I conducted interviews with public development companies in Thailand. All interviews were conducted virtually in Thai. Before the beginning of each interview, I told the participants about the purpose of the study. Participation was voluntary. All of them were aware that their names and companies would be kept confidential. They reserved the right to refuse to answer any of the questions or withdraw from the study at any time without any negative consequence.

Each interview lasted approximately 40-60 minutes. Through inquiry, I asserted that the participant provided meaningful insight based on their knowledge about the industry. To be qualified to take part in this research, the participants had to meet the following criteria:

- Above the age of 18.
- Works at the real estate development company
- Works at a company that specializes in commercial and residential development
- Manager or higher position at the company

Open-ended interviews were the primary method to collect data in this study. The method allows free responses to discover genuine opinions. At the beginning of the fall semester, I asked the participants to schedule interview sessions, and they had the option to choose to do a video conference or telephone call. The interview session was first conducted by asking for each participant's personal information, such as their name, age, gender, and position. Then, each participant was asked several questions describing their perspectives on the study. Participant details are outlined in the following table:

Table 1: Participants information for the qualitative interview

No.	Name	Gender	Company	Position	Development Location	Has a goal to achieve net zero	Asset Type
1	Dina	F	A	Sustainability Director	Bangkok	Yes	Residential
2	Paula	F	B	EVP Sustainable Development	Bangkok & other cities	Yes	Residential/ Commercial/ Industrial
3	Paul	M	C	Business Development and Strategy Partnership	Bangkok	No	Residential
4	Dimitri	M	D	Chief Marketing Officer	Bangkok	No	Residential
5	Charles	M	E	Chief Executive Officer	Bangkok Metropolitan	No	Residential
6	Sara	F	F	Head of Sustainability Development	Bangkok & other cities	Yes	Residential/ Commercial
7	Harry	M	G	Chief of Project Development & Chief of Strategic Marketing and Sustainability	Bangkok & other cities	Yes	Commercial
8	Sam	M	H	Chief Strategy Officer	Bangkok & other cities	No	Residential
9	Peter	M	I	Executive Officer Property	Bangkok	No	Residential
10	Steven	M	J	Senior Vice President	Bangkok	Yes	Residential/ Commercial
11	Tim	W	K	Managing Director	Bangkok & other cities	Yes	Residential

Qualitative coding is utilized to categorize the data to find themes and patterns. It allows me to structure unstructured transcripts from in-depth interviews into themes and patterns for analysis.

5. FINDING

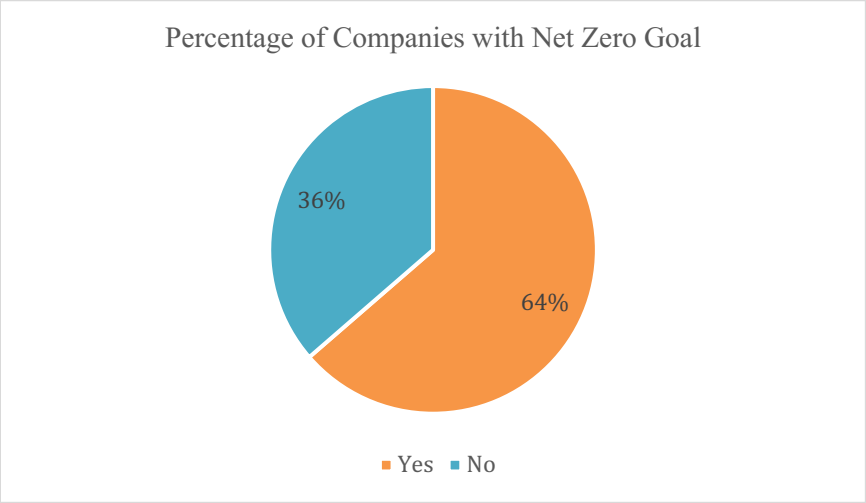


Figure 4: Percentage of the participant companies with net zero goal

The perspective of developers toward net zero

Seven out of eleven participants set the goal to achieve net zero by or before the national plan in 2065. They believe that Thailand's real estate industry will also accomplish the goal on the condition that the whole value chain and government have an aligned plan. The value chain includes the capital market, construction sector, developers, owners, occupiers, and employees. For the participants that do not have the plan to achieve net zero, they are observing the current regulations and policies before they take further action. If net zero is not mandatory, these companies most likely will not set a goal to achieve it. Participant M stated that the company wants to achieve the net zero goal. However, the company lacks the expertise to measure, report, and evaluate the pathway to reducing carbon emissions and the cost related to development.

All participants agreed that Thailand's real estate industry is driven by the private sector more than the governmental push. Circular Economy in Construction Industry (CECI) is a private organization formed to ensure that the Thai construction sector is expanding sustainably, encourage resource efficiency and minimize environmental consequences across the supply chain. It also aims to create a network for five sectors in the industry, including architecture and design, development, construction, construction material, and construction waste management service to achieve a low-carbon society. The organization highlights the importance of the environment for the development sector, efficient use of energy and natural resources, and waste management during construction. 55% of the participants' companies joined CECI, representing 26% (6 out of 23) of the total organization members. The participation illustrates that Thai developers are

working toward lowering embodied carbon in the real estate life cycle, despite no net zero regulation. Nevertheless, they would like to receive more support from the government to encourage a circular economy in the construction industry.

What drives real estate developers to adopt net zero practice in Thailand?

Competitive Advantage

Sustainability and ESG factors are becoming popular topics in Thailand, especially after Thailand committed to achieving carbon neutrality by 2050 and net zero by 2065. Eight out of eleven participants embraced net zero for a competitive edge. Even though there is no intense pressure from the government, customers, employees, and lenders, developers believe that the organization must take positive action on net zero to maintain its competitive advantage as a market leader.

Most companies that plan to achieve net zero do it voluntarily as part of the company's vision. Company J's vision is for "all well-being." The company has sustainability and innovation research and development companies to gather and share knowledge with other developers in the market. Company G has the vision to build a better future, including "applying sustainable development across every aspect of our [their] business to create long-term value for all stakeholders in the value chain." Company F aims to develop places "for the people and the planet" by applying green and well-being standards for all new developments and retrofitting existing ones.

Four of seven companies with the ambition to achieve net zero have a comprehensive goal and detailed action plans. All of those companies have commercial developments, which may put more pressure on the firms to achieve net zero. All aim to reduce carbon emissions from the business as usual against their comparative year in 2030 and reach net zero in 2050. They have incorporated climate considerations into their business plan. Company H also mentioned that "it is a defensive move to consider net zero." The company needs to adjust according to the new industry landscape standard. Company F perceived net zero to be very important for their retail developments. The energy saving helps them save high monthly electricity costs from air conditioning and lighting systems. Thus, it helps the company reduce its main operational cost and create a higher value.

Marketing and Branding

All companies, including those that do not have a net zero plan, believe that a net zero goal is part of the marketing and ESG strategy. All companies, including companies that do not plan to decarbonize,

mentioned that "net zero is part of corporate social responsibility." With the increased awareness about sustainability, it is beneficial for companies to promote their ambitions. The companies set various net zero goals and pathways with different standards. Some companies impose only corporate-level and some set corporate and asset-level net zero goals. Four out of eleven companies aim to achieve net zero energy building and reduce carbon emissions on the asset level.

Even though commitment and actions are different, there is a momentum toward decarbonization commitment. Some residential developers that develop and sell assets aim to achieve net zero for Scopes 1 and 2 at the corporate level. The reason is that the energy usage embodied carbon has contributed to their scope 3. It is difficult to collect the energy usage of the buyers and embodied carbon from the construction suppliers. There are limited technology and data capacities for these firms. In addition, they focus on low-cost solutions to keep housing affordable in the Thailand market. Some residential developers committed to net zero on the asset level. However, the pathway is unclear. They are now engaged on an ad hoc basis to reduce carbon emissions but are about to adopt a more strategic strategy. The data capacities and technology are still limited. Three participants representing commercial developers whose companies also own assets aim to reach net zero in Scope 1 and 2 and material activities in scope 3. These firms committed to international standards and applied for green certifications. Their corporate sustainability strategies incorporated the carbon emissions reduction plans with a clear roadmap to deliver their ambition. Nevertheless, the technology and data capabilities are in the process of development.

In addition, affordable green or net zero certificates can incentivize developers to adopt net zero. The certificate can certify the developers' assets as green assets and prevent the occupiers from a misleading brown development. A participant in Company B said, "there should be an affordable green certificate for net zero building in Thailand to add credentials to the building." Many participants also agreed that a certificate could be used to advertise their developments to attract occupiers looking for a space that aligns with their sustainability goal. Currently, the cost of green certification for commercial buildings and residential homes is costly, which defer some developers have to apply. Thus, affordable green or net zero certificates can encourage developers to develop net zero buildings.

Technology

There are technological advancements that reduce the cost of developing green residential and commercial real estate. The solar panel has been adopted in Thailand's real estate industry with a faster payback period in recent years. Developers who operate the assets benefit directly from the cost saving and are incentivized to install the technology. Commercial developers have been installing solar panels on the roof of buildings

and parking areas to increase renewable energy off-grid. Housing developers cannot offer solar panels for home buyers because it will drive the housing price above the market rate. They often provide it as an option to install. However, consumers rarely install solar panels because of the upfront cost for the installation, even though it will reduce the operational energy cost and benefits buyers in the long term.

Thailand developers also invest in more efficient cooling technology, such as air-conditioners and thermal roof envelopes. However, there is a slow adoption of cooling technology. A participant from Company G stated that "the company wanted to invest in high-efficiency technology that will help save energy and lower carbon emissions in the building; however, there are no repair parts available in Thailand. I cannot risk not having the air conditioning not operate for five days before the parts arrive from the manufacturing country." As a result, it prevents developers from adopting the technology.

The finding illustrates that commercial developers adopt new technologies faster than residential developers. When the technologies and repair parts are available in the market, and the market is mature to understand the benefit of energy reduction, developers are likely to implement new technology for greener developments.

How can the Thai government help real estate developers achieve net zero?

Funding for Technology Advancement

The participants stated that a government subsidy on infrastructure and digital solutions would help them adopt net zero. High-energy infrastructure technology exists; however, the cost of implementation does not generate an attractive return for the developers in Thailand. In addition, 7 participants' companies are unsure which infrastructure they should upgrade and to what extent to meet the net zero goal. There is lacking open~~ed~~ source knowledge and best practice~~s~~ case studies in Thailand. Thus, achieving net zero is more difficult for companies that do not have a research and development team that targets the mass market. Participating companies targeting the luxury market are more informed about the technologies available and implementation. Another green infrastructure technology challenge mentioned by 4 participants is the maintenance parts and services currently unavailable in Thailand. Therefore, developers want the government to subsidize the investment cost, provide a knowledge database, and support the manufacturing of high energy efficiency infrastructure domestically to solve the infrastructure technology problems.

Digital solutions technology is also crucial for developers to reach the net zero goal. Participant from Company J wanted to adopt architecture design software, such as BIM and Revit, to reduce construction

waste and increase functional building design. However, the cost of the software prevents architects in Thailand from adopting it. Not many architecture firms are experts in using the software. As a result, it is costly for developers to hire designers who can use the software to reduce carbon emissions. 7 participants mentioned that they want an affordable, flexible building solution available in the market. This technology can help developers to collect and optimize building energy usage and compare it to the benchmark, manage building operations more efficiently, and retrofit underperforming buildings. Therefore, the government can help developers to reach net zero by promoting the use of designing software and increasing adoption in the designing sector, as well as promoting building optimization software.

Subsidizing Occupiers' Cost

9 out of 11 participants reported a high investment cost embedded in reaching net zero because the occupiers are not willing to pay for green premiums. There are few studies on the total investment cost of net zero development, so they are unsure how much it would cost the developers. The cost cannot pass through to all segments of the end users, even though they benefit from energy savings and other health benefits. In Thailand's market, occupiers are more aware of sustainability, but not net zero. In addition, sustainable home, office, and retail space is a "good to have factor" for occupiers. Company G said that office occupiers prefer green buildings for the office spaces but are not required. 8 participants said that residential buyers in condominium and detached houses are unwilling to pay the premium for net zero homes. Nevertheless, the luxury residential market might have a faster adoption rate because they are more likely to invest in long-term benefits.

Retail occupiers are also not willing to pay for the net zero leases. International chain stores, such as Starbucks and KFC, work on their corporate sustainable goal toward net zero. Still, they are not choosing the location from high-efficiency buildings or paying a premium for sustainable developments. However, the participant hopes to build a green partnership with international chain stores.

The findings concluded that the developers would like the government to educate and push the consumers to adopt net zero and subsidize the end users' premium to own or rent the space to make the space more affordable.

Government Incentives

All participants agreed that there is a lack of tax, FAR bonus, fast track, and green material incentives from the public sector to accelerate decarbonization.

All participants believe that tax incentives can stimulate net zero investments to help the country achieve the net zero goal in 2065. Property tax, transfer tax, and income tax abatement can reduce developers' liabilities and increase the bottom-line profit. Tax abatement can come as a tax rebate or credit form. Tax incentives can counterbalance the negative impact of the higher asset value from the investment.

Increasing density or bonus FAR can encourage developers to adopt net zero. The participant from company B mentioned that not many companies in Thailand apply for TREES to increase FAR because it is risky for developers through the evaluating and permitting process. The participant said, "it is possible that we apply for TREES, develop the development with the bonus FAR, and do not receive the certificate." Learning from TREES, the public sector can offer bonus FAR with the evaluating and permitting process that mitigates such risks, such as a fully electrified building receiving a 20% bonus FAR.

Participant A mentioned that the permitting process in Thailand sometime could be slow and delay their project timeline since no construction can take place before the building permit has been issued. The permitting fast track can benefit developers by tying up a developer's capital and accumulating fees and interest expenses, as well as ensuring that the construction is not delayed because of the permitting. Fast track for a building permit can also incentivize the developers to decarbonize.

Subsidizing green materials can drive developers to reduce carbon emissions in the building lifecycle. It can be in the form of grants, tax credits, loans, or subsiding directly to the construction material companies. Currently, in the market, green materials cost higher than traditional materials. The incentive can help the developer maintain the construction cost and the selling price for a net zero building to achieve the expected return.

Providing Measurement Framework

All participants agreed that Thailand lacks a standardized framework to measure greenhouse gas emissions. Some companies want to set a goal; however, expertise, cost, and time prevent them from achieving it. Since they cannot measure GHGs, it is difficult for them to decide to reach the net zero goal. Currently, public limited companies are required to report sustainability reports. However, carbon emission is not mandatory. Therefore, individual companies created their reporting method, which may differ from other companies. Seven participants that set the goal of achieving net zero mentioned that they need transparent reporting information, method, and framework to monitor data and benchmark against the baseline. The participants do not only think about Scope 1 and 2 but also Scope 3. Scope 3 includes downstream and upstream measurements. Downstream includes waste and occupiers' energy usage, which are material in

their business. Upstream consists of the embodied carbon associated with the building materials and construction. This shows the developers have an appetite for learning about the whole net zero investment life cycle. Company F has a platform to report greenhouse gas emissions where all departments can input the value to generate GHG emissions. However, the platform lacks the flexibility to change activities, and sometimes the factors can be outdated. Therefore, the government sector can support developers by creating a standardized guideline and framework with flexibility to measure GHG emissions for the asset lifecycle.

6. Global Case Studies

From the finding, the developers drive the real estate sector to achieve net zero goals. However, there are no net zero policies and government support in this sector specifically. I understand that for a developing country, the government has to balance the net zero initiative against the negative impacts of slower economic growth, higher production costs, lower purchasing power, and social welfare losses. Clarity on policy is one of the essential factors in minimizing the transition risk.

In this discussion, I would like to learn from the three countries, the United States, Singapore, and Amsterdam, how the government helps the country implement net zero based on the findings. This thesis will help the policymakers regulate the sector and inform the developers of the possible regulations that will be implemented.

USA and California Overview

The United States has federal policies and state policies that vary across the States. In this chapter, I will study California because the State has a firm policy for net zero and have the closest climate to Thailand.
The United States rejoined the Paris agreement on January 20 and committed to a long-term strategy to achieve net zero by 2050 at the latest ("The United States Government," 2021). In 2021, the US also set the target to reduce net greenhouse gas (GHG) by 50-52 percent. At the 27th UN Climate Conference (COP 27), the US committed to leading a clean energy future by leveraging market forces, technological innovation, and investments ("The International Institute for Sustainable Development," 2021). The United States will demonstrate its commitment to a clean energy future at the 27th UN Climate Conference (COP27) by utilizing market forces, technological advancement, and investments to confront the global warming crisis. It will also work with its partners from vulnerable developing nations to help them build resilience to the issue ("The United States Government," 2022).

California

The California Climate Crisis Act (AB 1279), which came into effect on September 1, 2022, was approved. The policy states that by 2045, statewide anthropogenic greenhouse gas emissions must be at least 85% lower than in 1990. The State must achieve net zero greenhouse gas emissions as soon as technologically possible, but no later than 2045. After that, it must achieve and maintain net negative greenhouse gas emissions ("State of California." 2022). All new homes and business construction in California have to be zero-net energy by 2020 and 2030, respectively (Gupta et al., 2019)

Technology Support

Electric Program Investment Charge (EPIC) was established to fund research to develop and advance new energy solutions, promote regional innovation, and commercialize ideas from the lab. The State of California Energy Commission provides the analysis to support carbon reduction in the real estate sector. The State of California Energy Commission focused on Zero-Net Energy (ZNE) buildings at the lowest possible cost for developers. They also provided research to support the gap in adopting each Zero-Net Energy technology in the building sector by investigating 500 stakeholder surveys, literature reviews, and expert interviews. This research studied 150 technologies and summarized each technology by building type and climate, cost and performance, significant constraints, and research gaps. The researchers identified the opportunities and pathways to overcome the barriers to the technology gap, which contributed to 60 technologies. ZNE Technology Assessment and Prioritization (zTAP) tool identifies and prioritizes technologies based on the energy benefit, load shaping potential, and reduction of greenhouse gas emissions (Energy Research and Development Division,22).

Government Incentive

California provides many incentives for developers to developers to decarbonize the real estate industry. California allocated 3% of the state spending to tackle climate change over five years (California Environmental Voters, 2022). California building code sets a higher standard for buildings to be more energy efficient based on the performance of the buildings. Therefore, electrification gives the developer one of the most attractive returns because of grants and long-term operational benefits. Under California Scope Plan 2022, the government grants $922 million to Equitable Building Decarbonization Program to help the most vulnerable residents to retrofit buildings and replace fossil fuel appliances with electric appliances, energy-efficient lighting, and building insulation and sealing. The grant also supports the transition from gas infrastructure in specific geographic areas (State of California, 2022). The government also proposed Southern California Edison's (SCE) Electrification Programs to install heat pumps and electrical upgrades for homes and businesses with a 730 million USD government fund (Velez & Borgeson,

2022). The district also provides additional incentives for developers to adopt all-electric homes, solar photovoltaics, and electric vehicle charging on all new non-residential construction. For example, the City of Berkeley provides a transfer tax rebate for electrified home buyers (City of Berkeley, 2021).

Measurement and Framework

For the US, Securities and Exchange Commission (SEC) rule requires public companies to report GHG emissions, audited climate-related financial risks and metrics, and potential physical risks from climate change (Boyer, 2022). The Greenhouse Gas Protocol framework must be used as a guideline to disclose. Scope 3 may be exempted from declaration if it does not pass the materiality test. SEC provides tools and information to assess investment risks (US Securities and Exchange Commission, 2022). The new rule will help investors evaluate the company's exposure to climate risk management, including transition risk. California requires owners of large commercial and multifamily buildings with a GFA of more than 50,000 sq. ft. to report energy use to the California Energy Commission annually using Energy Star Portfolio Manager (California Energy Commission, 2020). It is an interactive tool where owners can benchmark the building's energy efficiency against the market. Climate Corporate Accountability Act (SB260) requires companies that do business in California with annual revenue exceeding 1 billion USD to disclose their GHG emission, including Scope 1, 2, and 3, and verified by a third-party auditor and approved by California Air Resources Board (Coleman, 2022). Even though it did not pass the second chamber because Scope 3 is subjective and challenging to regulate out-of-state emissions, there is a strong movement toward transparency and GHG reporting (Posner, 2022).

Netherlands and Amsterdam Overview

Under the Dutch Climate Act, the Dutch government has committed to achieving net zero carbon emissions by 2050. This Act aligned with the Paris Agreement's emission targets. The Dutch government has set programs, and action plans to attain net zero emissions for all buildings. It aims to achieve net zero emission transportation by 2050 and finish the energy transition by that time (Ministerie van Algemene Zaken, 2021).

The Dutch Climate Agreement outlines the ambitious goals to decarbonize the building industry over the next few decades. The Netherlands has pledged to cut greenhouse gas emissions by 95% and by 49% by 2030 compared to 1990 (Amsterdam Climate Neutral programme team Management, 2019). Currently, 95% of the building stocks utilize natural gas. The foremost step for the country to transit is to make all buildings natural-gas-free by 2050 with the support of the local government. The transition would

significantly impact the residential sector. For the non-residential sector, new measures are proposed for higher energy efficiency standards (Caloia et al., 2022).

Amsterdam is the leader in moving toward a circular economy with the policies' direction specific to different sectors to guide public and private decision-making. Amsterdam aims to reduce CO2 emissions by 55% in 2030 and 95% in 2050. The city will transit away from natural gas before 2040. In 2050 Amsterdam will be a circular city where everything will be reused to produce and consume. For the built environment, the city looks beyond the operation carbon and tackles embodied carbon by promoting adaptable design and reusing building materials. Under the Amsterdam Circular Strategy 2020-2025, new raw materials must be cut in half by 2030 to achieve a fully circular city by 2050 (Municipality of Amsterdam, n.d.). The Circular Economy relies on all stakeholders' engagement, including central government, municipality, builders, private property owners, energy companies, financial institutions, community, and residents, to participate in the ambition.

Technology Support

Amsterdam municipality collaborates with international, national, regional, and local support experimentation and innovation to transform the city into a climate-neutral city. On the city level, NetZeroCities is the online platform to support the city in creating systemic change. The pilots and Twinning program enable peer learning and promote the change adoption throughout Europe. The European Union (EU) provide an EIT Benelux platform for the communities to access tools, resources, and expertise to learn about innovative products, services, and system that can scale up for impact. It also identified sources for public and private funding to stimulate innovations. The municipality also supports developers and homeowners to achieve carbon-neutral and positive energy buildings.

Government Incentive

Amsterdam supports and incentivizes developers to decarbonize and phrased out from natural gas. Amsterdam Environmental Management Act and Energy Efficiency Directive are enforced to push developers to achieve the goals. As of January 2021, energy performance required all new residential and non-residential buildings to be NZEB. The energy performance will be calculated based on NTA 8800 calculation method (Caloia et al., 2022). Developers can choose the most cost-efficient solution as long as the energy criteria are met. Office buildings are required to certify at least energy label C standards, and housings have to meet D standards. If the standards are not met, renting the space can be prohibited.

Nevertheless, a green premium is proven to offset the higher investment cost. The government provides resources, such as cash incentives and subsidies, for businesses and residents to comply with the enforcement. The city also offers free energy consultations to scale up the ambition to reduce emissions (Sustainability Council Commissioner 2022). The government also emphasizes the circular city with the 2030 goal to use 50% fewer raw materials and at the latest in 2050 to become a circular city. The regional government also provides flexible zoning, consultation, and data to developers for circular area development. The national government adjusts the legal framework to facilitate circular development projects with supporting services and guidelines for municipalities and businesses (Kouloumpi et al., 2019).

Measurement and Framework

Amsterdam is one of the leading cities to reduce GHG emissions, and GHG accounting is highly mature compared to other cities. The city follows the regulation of the European Union. The EU adopted the new Corporate Sustainability Reporting Directive (CSRD) in October 2022, which required companies to report Non-Financial Reporting Directive (NFRD) according to European Green Deal. The sustainability report, including the GHG reporting, would require not only public companies in the EU market but also large EU subsidiaries of non-EU companies and non-EU companies with substantial activities in the EU market (Wollmert & Hobbs, 2022). Partnership for Carbon Accounting Financial (PCAF) was founded in the Netherlands in 2015. PCAF continuously improved GHG accounting standards and calculation accuracy to align with the Paris agreement (PCAF Netherlands, 2022) PCAF provided a transparent standard for measuring financed emissions, including the European building emission factor database. PCAF provided a guideline for financial institutions to decarbonize their building portfolio, requiring the asset manager to (1) measure and disclose GHG emissions, (2) set climate targets, (3) develop a strategy for implementation and (5) take action. The financial market can incentivize developers and asset owners to decarbonize (PCAF, 2022).

Singapore Overview

In October 2022, Singapore raised the Nationally Determined Contribution (NDC) emissions target to peak at 60MtCO2e early in 2030 from 65MtCO2e. The country also targeted to achieve net zero by 2050 as part of its Long-Term Low-Emissions Development Strategy (LEDS). These goals are subject to technological maturity and adequate international support.

Technology Support

Singapore also aims to be a net-zero carbon city and push for Super Low Energy Building (SLEB). The local government implements pilot and demonstration projects before scaling them up after adjusting the technology, delivery methods, policies, and business models (Lam et al., 2022). Singapore National Research Foundation also funded SLEB Start Hub to support developers in implementing innovative green technologies aligning with Singapore Green Building Masterplan and BCA Green Mark certification criteria. The one-stop online platform informs developers about green technologies and building energy data. With the national database and artificial intelligence, developers can benchmark their buildings and learn insights from high-performance buildings. The platform also provides green investment recommendations and implementation costs (Building and Construction Authority, 2020). To implement the plan, Singapore also launched Built Environment Industry Transformation Map (BE ITM) program to integrate the building's life cycle from planning and design, construction to operations and maintenance. This integrated platform helps the stakeholders to collaborate to reduce embodied and operational carbon footprint in the value chain (Building and Construction Authority,2022).

Government Incentive

Singapore pushes and pulls the real estate industry to decarbonize with the Green Mark Scheme. Green Mark scheme 2021 increase energy performance standard and focus on reducing carbon emission throughout the building's life cycle. It highlights the integration of intelligent technologies, healthy buildings, and the reduction of embodied carbon (Building and Construction Authority, 2021). Since July 2013, all new construction and all existing buildings with a gross floor area of 15,000 m2 or greater are required by the Building Control Act to meet the minimum Green Mark requirement. Occupation permits will not be granted for buildings that do not meet the minimum standard (Cities Climate Leadership Group, 2015). Green Mark Gross Floor Area Incentive Scheme and Built Environment Transformation Gross Floor Area Incentive Scheme provide additional GFA for developers who acquire the higher ratings standard and adopt enhanced Construction Industry Transformation Map (ITM) standards, respectively. The cash incentive will be granted to lower upfront costs to achieve higher energy efficiency standards under GMIS for Existing Buildings 2.0. The Building and Construction Authority (BCA) also launched Building Retrofit Energy Efficiency Financing (BREEF) Pilot Scheme to encourage building owners to retrofit. The authority will also share loan defaulting risk with the financial intuitions to provide loans to building owners to retrofit (Building and Construction Authority, 2022).

Standardization and Framework

In December 2021, the Singapore Exchange (SGX) issued a standard set for core ESG metrics for public companies. The metrics required the company to report GHG emissions, energy consumption, water consumption, and waste generation (Asprey, 2022). The country's financial regulator also issued guidelines on environmental risk, criteria, and thresholds for GHG emissions for the real estate sector. The real estate sector can explain if it does not comply until 2025 (Asprey, 2022). Building Control Act in Dec 2012 mandated commercial building owners to report building information and utility usages for BCA to monitor environmental sustainability standards and overall energy performance of the building stocks through the Building Energy Submission System (BESS) (Building and Construction Authority, 2014). The provided information is analyzed to help create future building energy efficiency policies and better understand the trends in commercial buildings' energy consumption.

7. CONCLUSION, LIMITATION & OUTLOOK

Thailand

Currently, there is a timeline but no clear pathway for the building industry to decarbonize. Therefore, in this section, I will apply the learning from California, Amsterdam, and Singapore to help developers adopt net zero.

The gap in the Adoption of Technology Advancement

From the finding, the developers are uncertain about the technologies to reduce carbon emissions and the cost-benefit related to the technologies. Learning from California, Amsterdam, and Singapore, the Thailand government can support the industry with knowledge platform sharing and green technology research to help Thai developers to adopt technologies to reduce emissions.

Since net zero is new in Southeast Asia, Southeast Asian governments can join forces to build a platform similar to NetZeroCities to launch a program that supports the developers with the solution to achieve the net-zero goal in a socially inclusive way. The platform provides each technology's information, including cost and benefits, similar to the BE ITM platform in Singapore and research done by the State of California Energy Commission in California. The collaboration can provide fast learning and data for developers in all countries in a similar climate.

In addition, the government can facilitate knowledge sharing by providing case studies of the developments. Government can pilot public building projects to demonstrate the viability of net zero buildings. To increase case studies available for the knowledge hub, the government can provide funding to stimulate design that can reduce energy and carbon embodied.

An energy benchmarking platform can be enforced for all building owners to report their energy usage. The platform can track energy efficiency in each development, allowing stakeholders to monitor and benchmark their developments against their peers. The platform will also help the government sector to collect data and use it to implement the appropriate policies. The financial sectors can retrieve the data to assess climate risks and identify stranded assets.

The gap in the Adoption of Government Incentives

The policymakers may use the stick a push in the real estate sector to reduce carbon emissions. Learning from the developed countries, all studied countries mandate new and retrofit buildings to achieve net zero aligned with national goals. Only carrots may not be able to push the industry toward net zero. Therefore, Thailand needs to establish adequate and efficient policies to integrate with the LT-LEDS. Policy enforcement is one of the challenges in Thailand. The government may need to designate regulators to help with the process. For example, the environmental impact assessment (EIA), under the Office of Natural Resources and Environmental Policy and Planning, can be updated to be more energy efficient, aligning with the limiting global temperature rise to 1.5°C. EIA will enforce large commercial development. An additional renovation wave may follow to decarbonize the existing buildings. For the mature stage, the building code, which is a requirement for the building permit under the Department of Public Works and Town & Country Planning, can be updated to enforce all developments to be net zero. Thailand is a developing country; imposing a tax on low-energy efficient buildings will slow the country's growth.

Achieving net zero across all existing and new developments is a challenge for developers. Therefore, incentives are needed to support developers. Governments in different cities provide different incentives in terms of tax credits and grants. Since Thailand is a developing country, it can collaborate with the UN for sustainable development funding. Net zero buildings increase the property value, and as a result, it will increase property tax which can be used to incentivize developers to decarbonize.

Tax incentive stimulates growth as it increases the profit margin for the developer. To balance the higher investment cost and the higher property value, the government can provide a property tax credit for green technologies, such as high-energy efficient air conditioners, lighting systems, solar panels, and EV charging stations. Government can incentivize commercial and residential building owners and tenants to retrofit by

providing tax reductions for building energy-efficient improvements with greater than 50% energy savings. To promote electrification in the housing market, the government can give a property tax transfer rebate for housing since it is contributed to the highest number of transactions.

Learning from Green Mark Scheme, the authority can also provide a green certificate for low carbon emissions development with the incentive to increase FAR for the highest rating. The certificate will signal the buyers and investors for high-energy efficiency buildings. The authority can also provide a special certificate to reward net zero whole life cycle assets from the building's design, construction, operation, and maintenance to demolition because carbon embodied contributed to the significant carbon emission in the asset life cycle.

Learning from Amsterdam, the government can provide free net zero buildings and circular economy consultation to help developers achieve net zero. Large private companies joined the force to learn about the circular economy from CECI. However, the concept and know-how are not adopted among mid and small-size firms. With one-on-one consultants, net zero and circular economy can be broadened to be embraced among all companies.

Green premiums and grants to the occupiers will allow the developers to offset the increase in the investment cost. With the education regarding the benefit of net zero and green certificate, "Green Premium" may be possible to increase the commercial and residential prices and rent. To maintain affordability in the housing sector, the government can learn from California and Singapore incentives to provide cash to the end users to purchase and rent low carbon residentials.

The gap in the Framework and Guideline

The government can support the real estate industry with a standardized framework and guidelines for the real estate industry aligning with the Greenhouse Gas Protocol. Thailand's GHG report is relatively new compared to California, Amsterdam, and Singapore. Clear indicators, standardized data, and methodology are essential for developers to estimate their building emissions and set net-zero targets. Calculating and tracking direct and indirect emissions from scopes 1 to 3 can be a challenge for developers in Thailand to gather and continuously analyze the information. Corporate reporting boundaries can be different from building (asset-level) reporting boundaries. The standardized framework will help developers and owners to build complete and accurate data to verify the ongoing efforts are on track, set the right strategies for climate action, and disclose progress to their stakeholders. In addition, user-friendly tools for the real estate industry to report the GHG can accelerate the adoption.

Moreover, transparent, harmonized standards are vital for investors and financial institutions to form innovative financial products and services to stimulate investors to invest in net zero. The financial regulators and the policymakers can align their actions to accelerate the building transition. Currently, green bonds and green loans are available in the market. With the standardized matric and framework, it will give accessibility for developers to more sophisticated financial instruments and create economic benefits from emission reduction.

Conclusion

Thailand set a national target to achieve net zero by 2065. However, no policy or building code regulates the real estate industry to align with the net zero goal. Developers in Thailand announced net-zero ambition voluntarily. The initiatives vary across the companies. Developers in public companies believe that net zero is essential to maintain competitiveness, and it is used as a marketing and branding tool to promote sustainable goals. In addition, green technologies are more available in the market.

To transition to net zero, developers want the Thai government to support developers by providing technology knowledge, incentives, framework, and guideline. Knowledge platform is crucial for developers to learn about available technologies, cost-benefit for investment, and net-zero case studies. Easy-to-access research can fill the knowledge gap and accelerate the adoption. The government can allocate the country's budget and apply for UN funding to provide an incentive for the real estate industry to decarbonize. Encouragement can be in the form of a tax rebate or credit to help developers with the higher investment cost and avoid passing through the cost to occupiers. Higher FAR can incentivize developers to decarbonize because of the higher salable or rentable revenue. To maintain affordable of the residential sector, the government can provide cash for occupiers who purchase net zero homes. With a higher adoption rate and education in net zero, the green premium might be possible for developers to increase the price and rent. At the same time, the occupiers' saving occurs from lower energy costs. Measurement and framework guidelines will help developers to calculate, report and benchmark their assets, as well as strategize efforts to decarbonize. The framework and measurement will help developers, policymakers, investors, and financial institutions mitigate climate risk.

Limitation & Outlook

The research is limited in several ways, providing opportunities to build on the study. Only participants from Thai public development companies in commercial and residential markets were interviewed in this study. This may not represent private real estate developers and industrial developers. The discussion only focuses on the support that the participants want from the public sector. The economic behind the government's support to achieve net zero was not studied.

APPENDIX:

9. GLOSSARY

- Net zero refers to a state in which the greenhouse gases going into the atmosphere are balanced by removal from the atmosphere.
- A carbon dioxide equivalent or CO2 equivalent refers to a metric measure used to compare the emissions from various greenhouse gasses based on their global-warming potential (GWP) by converting amounts of other gasses to the equivalent amount of carbon dioxide with the same global warming potential.
- Zero-emission building (ZEB) refers to an energy-efficient building where, on a source energy basis, the actual annual consumed energy is less than or equal to the on-site renewable generated energy.
- Green loans refer to loans meant for sustainable, environmentally friendly purposes, such as reducing CO2 emissions, or purposes contributing to the green transition in society, such as developing new environmentally friendly technology.
- Embodied carbon refers to the greenhouse gas emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials.
- Decarbonization refers to reducing carbon intensity by lowering the amount of greenhouse gas emissions produced by burning fossil fuels.
- Operational carbon emission refers to the amount of carbon emitted during the operational or in-use phase of a building.

10. TABLE OF TABLE & FIGURES

Table of Figures:

Figure 1: Share of final energy consumption by economic sector, 2020 (Ministry of Natural Resources and Environment, 2022) ……..…….…….……...……..8
Figure 2: LT-LEDS's net zero emission timeline for the residential sector (Ministry of Natural Resources and Environment, 2022)……...……..……...……..…. 9
Figure 3: LT-LEDS's Net zero timeline for the commercial building sector (Ministry of Natural Resources and Environment, 2022)…….....…….…… 9
Figure 4: Percentage of the participant companies with net zero goal……...…….. 16

Table of Table

Table 1: Participants information for the qualitative interview ……....15

11. BIBLIOGRAPHY

Amsterdam, G. (n.d.). *Policy: Circular economy*. City of Amsterdam. Retrieved December 18, 2022, from https://www.amsterdam.nl/en/policy/sustainability/circular-economy/

Ananwattanaporn, S., Patcharoen, T., Bunjongjit, S., & Ngaopitakkul, A. (2021). Retrofitted Existing Residential Building Design in Energy and Economic Aspect According to Thailand Building Energy Code. *Applied Sciences*, *11*(4), 1398.

Asprey, J. (2022, September 23). *Singapore ESG disclosure: MAS and SGX provide clear guidelines*. GoldenSource. Retrieved January 8, 2023, from https://www.thegoldensource.com/mas-sgx-provide-clear-guidelines-singapore-esg-disclosure/#:~:text=A%20year%20later%2C%20in%20December,water%20consumption%20and%20waste%20generation.

Boland, B., Levy, C., Palter, R., & Stephens, D. (2022, June 13). *Climate risk and the opportunity for real estate*. McKinsey & Company. Retrieved December 10, 2022, from https://www.mckinsey.com/industries/real-estate/our-insights/climate-risk-and-the-opportunity-for-real-estate

Building and Construction Authority. (2014). *Building Energy Benchmarking Report 2014*. Building and Construction Authority. Retrieved January 8, 2023, from https://www.bca.gov.sg/GreenMark/others/BCA_BEBR_Abridged_FA.pdf

Building and Construction Authority. (2020, September 28). *SLEB Smart Hub to accelerate green technology adoption*. Building and Construction Authority. Retrieved December 29, 2022, from https://www1.bca.gov.sg/buildsg-emag/articles/sleb-smart-hub-to-accelerate-green-technology-adoption

Building and Construction Authority. (2021, September 7). *Green mark 2021*. Building and Construction Authority. Retrieved January 8, 2023, from https://www1.bca.gov.sg/docs/default-source/docs-corp-buildsg/sustainability/20211028_certification-standard_r1-1.pdf

Building and Construction Authority. (2022, September 6). *Built Environment Industry Transformation Map to Facilitate Integration and Collaborative Breakthrough Across the Entire Value Chain*. Building and Construction Authority. Retrieved December 29, 2022, from https://www1.bca.gov.sg/about-us/news-and-publications/media-releases/2022/09/06/built-environment-industry-transformation-map-to-facilitate-integration-and-collaborative-breakthrough-across-the-entire-value-chain

Building and Construction Authority. (2022, November). *Green Mark Incentive Schemes*. Building and Construction Authority. Retrieved January 8, 2023, from

https://www1.bca.gov.sg/buildsg/sustainability/green-mark-incentive-schemes Cities Climate Leadership Group. (2015, November). *Singapore Greens existing buildings through Green Mark Certification, audit and benchmarking legislation package*. C40 Cities. Retrieved January 8, 2023, from https://www.c40.org/case-studies/singapore-greens-existing-buildings-through-green-mark-certification-audit-and-benchmarking-legislation-package/

California Energy Commission. (2020, May). *Building Energy Benchmarking Program Commercial Buildings*. California Energy Commission. Retrieved January 8, 2023, from https://www.energy.ca.gov/sites/default/files/2020-06/Benchmarking_Commercial_FS_ada.pdf

Caloia, F., Jansen, D.-J., Koo, H., van der Molen, R., & Zhang, L. (2022). *Real estate and climate transition risk A financial stability perspective*. De Nederlandsche Bank . Retrieved January 2, 2023, from https://www.dnb.nl/media/cniottiu/web_134119_os_real-estate_and_climate.pdf

Chongwilaikasaem, S., & Chalermyanont, T. (2022). Flood hazards and housing prices: a spatial regression analysis for Hat Yai, Songkhla, Thailand. *International Journal of Housing Markets and Analysis*, (ahead-of-print).

Cline, W. R. (2011). *Carbon abatement costs and climate change finance* (Vol. 96). Peterson Institute.

Coleman, L. W. (2022, February 16). *California poised to adopt stricter GHG reporting regulations*. EHS Daily Advisor. Retrieved January 8, 2023, from https://ehsdailyadvisor.blr.com/2022/02/california-poised-to-adopt-stricter-ghg-reporting-regulations/

Davies, A. (2022, June). *Achieving net-zero through corporate real estate investments*. Norton Rose Fulbright. Retrieved December 9, 2022, from https://www.nortonrosefulbright.com/en/knowledge/publications/28e8ded9/achieving-netzero-through-corporate-real-estate-investments

DeFries, R. S., Edenhofer, O., Halliday, A. N., Heal, G. M., Lenton, T., Puma, M., Rising, J., Rockström, J. Ruane, A. C., Schellnhuber, H. J., Stern, N., Tedesco, M. & Ward, B. (2019). The missing economic risks in assessments of climate change impacts.

Diewvilai, R., & Audomvongseree, K. (2022). Possible Pathways toward Carbon Neutrality in Thailand's Electricity Sector by 2050 through the Introduction of H2 Blending in Natural Gas and Solar PV with BESS. *Energies*, *15*(11), 3979.

Dhakal, S., & Shrestha, A. (2016). Bangkok, Thailand. In *Cities on a Finite Planet* (pp. 95-112). Routledge.

Energy Policy and Planning Office. (March 11, 2022). Carbon dioxide emissions per capita in Thailand from 2011 to 2022 (in metric tons per capita) [Graph]. In *Statista*. Retrieved January 13, 2023, from https://www.statista.com/statistics/1296632/thailand-co2-emissions -per-capita/

Energy Research and Development Division, Gupta, S., & Smith, J., Research Gap Analysis for Zero-Net Energy Buildings (2022). Energy Research and Development Division. Retrieved December 10, 2022, from https://www.energy.ca.gov/sites/default/files/2021-06/CEC-500-2019-031.pdf.

Gulzar, A., Islam, T., Gulzar, R., & Hassan, T. (2021). Climate Change and Impacts of Extreme Events on Human Health: An Overview. *Indonesian Journal of Social and Environmental Issues (IJSEI)*, *2*(1), 68-77.

Gupta, S., & Smith, J. *Itron. Research Gap Analysis for Zero-Net Energy Buildings: Final Project Report. 2019. Available online: https://ww2. energy. ca. gov/2019publications/CEC-500-2019-031*. CEC-500-2019-031. pdf (accessed on February 3 2021).

Hanson, S., Nicholls, R., Ranger, N., Hallegatte, S., Corfee-Morlot, J., Herweijer, C., & Chateau, J. (2011). A global ranking of port cities with high exposure to climate extremes. *Climatic change*, *104*(1), 89-111.

Higham, J., Font, X., & Wu, J. (2021). Code red for sustainable tourism. *Journal of Sustainable Tourism*, *30*(1), 1-13.

Houghton, R. A., & Woodwell, G. M. (1989). Global climatic change. *Scientific American*, *260*(4), 36-47.

IEA (2019), Global Status Report for Buildings and Construction 2019, IEA, Paris https://www.iea.org/reports/global-status-report-for-buildings-and-construction-2019, License: CC BY 4.0

Kaufman, D., McKay, N., Routson, C., Erb, M., Dätwyler, C., Sommer, P. S., ... & Davis, B. (2020). Holocene global mean surface temperature, a multi-method reconstruction approach. *Scientific data*, *7*(1), 1-13.

Kouloumpi , I., de Winter, J., Douma , A., Russell, M., van Berkel, P., & Köhler, J. (2019, June 19). *Building Blocks for the New Strategy Amsterdam Circular 2020-2025*. Circle Economy. Retrieved January 2, 2023, from https://assets.website-files.com/5d26d80e8836af2d12ed1269/5de954d913854755653be926_Building-blocks-Amsterdam-Circular-2019.pdf

Lam, K. P., Cossu, G., & Hee, L. (2022, March 7). *Singapore's methodical approach to becoming a net-zero city*. World Economic Forum. Retrieved December 29, 2022, from https://www.weforum.org/agenda/2022/03/singapore-methodical-approach-net-zero/

Le Page, M. (2021). "Make or break" is hardly hyperbole for the climate negotiations due to reach their climax in November in Glasgow, UK. At the COP26 meeting, nations will have a last chance to really rev up the stuttering motor of climate action and come good on commitments made in Paris in 2015 to limit global warming to a "safe" level of 1.5° C. *New Scientist*, *250*(3331), 34-45.

Lohwanitchai, K., & Jareemit, D. (2021). Modeling Energy Efficiency Performance and Cost-Benefit Analysis Achieving Net-Zero Energy Building Design: Case Studies of Three Representative Offices in Thailand. *Sustainability*, *13*(9), 5201.

Ministerie van Algemene Zaken. (2021). *Commitment cop 26: The Netherlands*. Climate change. Retrieved December 18, 2022, from https://www.government.nl/topics/climate-change/cop26-the-netherlands

Ministry of Natural Resources and Environment. (2022, November). *Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy (Revised version)*. United Nations Climate Change. Retrieved January 9, 2023, from https://unfccc.int/sites/default/files/resource/Thailand%20LT- LEDS%20%28Revised%20Version%29_08Nov2022.pdf

Misila, P., Winyuchakrit, P., & Limmeechokchai, B. (2020). Thailand's long-term GHG emission reduction in 2050: the achievement of renewable energy and energy efficiency beyond the NDC. *Heliyon*, *6*(12), e05720.

Municipality of Amsterdam. (n.d.). *Policy: Circular economy*. City of Amsterdam. Retrieved December 18, 2022, from https://www.amsterdam.nl/en/policy/sustainability/circular-economy/

Munpa, P., Kittipongvises, S., Phetrak, A., Sirichokchatchawan, W., Taneepanichskul, N., Lohwacharin, J., & Polprasert, C. (2022). Climatic and Hydrological Factors Affecting the Assessment of Flood Hazards and Resilience Using Modified UNDRR Indicators: Ayutthaya, Thailand. *Water*, *14*(10), 1603.

Muntean, M., Guizzardi, D., Schaaf, E., Crippa, M., Solazzo, E., Olivier, J., & Vignati, E. (2018). Fossil CO2 emissions of all world countries. *Luxembourg: Publications Office of the European Union*, *2*.

Nock, C. A., Baker, P. J., Wanek, W., Leis, A., Grabner, M., Bunyavejchewin, S., & Hietz, P. (2011). Long-term increases in intrinsic water-use efficiency do not lead to increased stem growth in a tropical monsoon forest in western Thailand. *Global Change Biology*, *17*(2), 1049-1063.

PCAF. (2022). *Guidance on financing the European building transition to net zero*. PCAF. Retrieved January 8, 2023, from https://carbonaccountingfinancials.com/files/downloads/pcaf-guidance-on-financing-the-net-zero-building-transition.pdf

PCAF Netherlands. (2022, November). *Updates from implementing GHG accounting for the financial sector in the Netherlands*. PCAF Netherlands. Retrieved January 8, 2023, from https://carbonaccountingfinancials.com/files/downloads/2210-pcaf-report-nl.pdf

Peterson, K.; Torcellini, P.; Grant, R. *A Common Definition for Zero Energy Buildings*; United States Department of Energy: Washington, DC, USA, 2015.

Posner, C. (2022, September 25). *California's proposed Climate Corporate Accountability Act Goes Belly up*. The Harvard Law School Forum on Corporate Governance. Retrieved January 8, 2023, from https://corpgov.law.harvard.edu/2022/09/25/californias-proposed-climate-corporate-accountability-act-goes-belly-up/#:~:text=Although%20the%20bill%20had%20sailed,to%20a%20%E2%80%9Cno%E2%80%9D%20vote.

Puybaraud, M., Coghlan, S., Kelly, J., Mabardi, L., Walia, R., & Miglani, K. (2021, June 20). *Decarbonizing the Built Environment*. Global Research l Responsible Real Estate. Retrieved December 11, 2022, from https://www.jll.co.uk/en/trends-and-insights/research/decarbonizing-the-built-environment

Rhodes, C. J. (2019). Only 12 years left to readjust for the 1.5-degree climate change option–Says International Panel on Climate Change report: Current commentary. *Science progress*, *102*(1), 73-87.

Ritchie, H., Roser, M., & Rosado, P. (2020). CO_2 and greenhouse gas emissions. *Our world in data*.

Samphantharak, K. (2014). Natural disasters and the economy: some recent experiences from Southeast Asia. *Asian-Pacific Economic Literature*, *28*(2), 33-51.

Sawangnate, C., Chaisri, B., & Kittipongvises, S. (2022). Flood hazard mapping and flood preparedness literacy of the elderly population residing in Bangkok, Thailand. *Water*, *14*(8), 1268.

Scott, D., & Gössling, S. (2021). From Djerba to Glasgow: have declarations on tourism and climate change brought us any closer to meaningful climate action?. *Journal of Sustainable Tourism*, *30*(1), 199-222.

Seo, S. N. (2017). Beyond the Paris Agreement: Climate change policy negotiations and future directions. *Regional Science Policy & Practice*, *9*(2), 121-140.

State of California. (2022, November 16). *2022 Scoping Plan for Achieving Carbon Neutrality*. California Air Resources Board. Retrieved December 13, 2022, from https://ww2.arb.ca.gov/resources/documents/2022-scoping-plan-documents

Sustainability Council Commissioner. (2022, April). *Climate Report 2022*. City of Amsterdam. Retrieved January 2, 2023, from https://www.amsterdam.nl/en/policy/sustainability/policy-climate-neutrality/

Swartz, Z., Peloso, M. E., & Snelson, C. (2022, March 31). *Real Estate Opportunities in the Energy Transition*. Vinson & Elkins. Retrieved December 10, 2022, from https://www.velaw.com/insights/real-estate-opportunities-in-the-energy-transition/

Tan, Z., & Zheng, S. (2022, May). *Towards a Zero-Emission and Resilient Real Estate Industry: Global Outlook and Asia's Progress*. MIT Center for Real Estate. Retrieved December 10, 2022, from https://cre.mit.edu/wp-content/uploads/2022/09/NetZeroWhitepaperES-0526.pdf

Tebakari, T. (2020). Use of high-resolution elevation data to assess the vulnerability of the Bangkok metropolitan area to sea level rise. *Hydrological Research Letters*, *14*(4), 136-142.

City of Berkeley. 2021.*Existing Buildings Electrification Study.* Retrieved December 13,2022, from https://drive.google.com/file/d/10OY_USkF2MeoBkLXuzQEewpW8rAm-WTk/view. 97

The International Institute for Sustainable Development. (2021, April 28). *US sets target to reduce emissions by 50-52% below 2005 levels in 2030: News: SDG knowledge hub: IISD*. SDG Knowledge Hub. Retrieved December 13, 2022, from https://sdg.iisd.org/news/us-sets-target-to-reduce-emissions-by-50-52-below-2005-levels-in-2030/

The United States Government. (2021, April 22). *Fact sheet: President Biden sets 2030 greenhouse gas pollution reduction target aimed at creating good-paying union jobs and securing U.S. leadership on Clean Energy Technologies*. The White House. Retrieved December 13, 2022, from https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/

The United States Government. (2022, November 11). *Fact sheet: President Biden announces new initiatives at COP27 to strengthen U.S. leadership in Tackling Climate Change*. The White House. Retrieved December 13, 2022, from https://www.whitehouse.gov/briefing-room/statements-releases/2022/11/11/fact-sheet-president-biden-announces-new-initiatives-at-cop27-to-strengthen-u-s-leadership-in-tackling-climate-change/

Ulbrich, C. (2022, January 12). *The conversation about green real estate is moving on as corporates prioritize sustainability*. World Economic Forum. Retrieved December 11, 2022, from https://www.weforum.org/agenda/2022/01/green-real-estate-sustainability-corporate-priority/

Carpenter, A., & Schantz, M. (2022, January). *ULI Global Sustainability Outlook 2022*. Urban Land Institute. Retrieved December 9, 2022, from https://knowledge.uli.org/en/reports/research-reports/2022/uli-global-sustainability-outlook-2022

United Nations Climate Change. (n.d.). *Thailand*. United Nations Climate Change. Retrieved January 12, 2023, from https://unfccc.int/node/61213

Velez, K., & Borgeson , M. (2022, February 24). *Ca building decarbonization: What's coming in 2022?* NRDC. Retrieved December 30, 2022, from https://www.nrdc.org/experts/kiki-velez/ca-building-decarbonization-whats-coming-2022#:~:text=The%20%2450%20million%20program%20will,income%20or%20historically%20disadvantaged%20communities.

U.S. Securities and Exchange Commission. (2022, March 21). *SEC Proposes Rules to Enhance and Standardize Climate-Related Disclosures for Investors*. U.S. Securities and Exchange Commission. Retrieved January 8, 2023, from https://www.sec.gov/news/press-release/2022-46.

Wein, J., Bienert, S., Spanner, M., Kuhlwein, H., Huber, V., Künzle Chiara, Ulterino, M., Carlin, D., & Arshad, M. (2022, March). *Managing Transition Risk in Real Estate: Aligning to the Paris Climate Accord*. UN Environment Programme. Retrieved December 11, 2022, from https://www.unepfi.org/themes/climate-change/managing-transition-risk-in-real-estate-aligning-to-the-paris-climate-accord/

Wollmert, P., & Hobbs, A. (2022, August 1). *How the EU's new Sustainability Directive is becoming a Game Changer*. Ernst & Young Global Limited. Retrieved January 8, 2023, from https://www.ey.com/en_gl/assurance/how-the-eu-s-new-sustainability-directive-is-becoming-a-game-changer

World Health Organization. (2015). *Climate and health country profile 2015: Thailand* (No. WHO/FWC/PHE/EPE/15.16).