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Financial Feasibility of Energy-Saving Residential Condominium

Miss Tita Chinsomboon

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science Program in Architecture

Department of Architecture

Faculty of Architecture

Chulalongkorn University

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ฐิตา ชินสมบูรณ์ : การประเมินความเป็นไปได้ทางการเงินของอาคารชุดพักอาศัยแบบประหยัดพลังงาน (Financial Feasibility of Energy-Saving Residential Condominium) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. ดร. วรสัณฑ์ บูรณากาญจน์{, 52 หน้า.

ตลาดอาคารชุดพักอาศัยในประเทศไทยได้แสดงให้เห็นถึงการเจริญเติบโตอย่างต่อเนื่อง อาคารเหล่านี้มีการใช้พลังงานสูงและเมื่อโลกนั้นกำลังประสบวิกฤตพลังงาน การที่จะทำให้คอนโดมิเนียมใช้พลังงานอย่างมีประสิทธิภาพและประหยัดมากขึ้นนั้นเป็นสิ่งที่สำคัญอย่างยิ่ง อย่างไรก็ตามการสร้างอาคารก็ต้องคำนึงถึงด้านของธุรกิจ แบบอาคารที่ประหยัดพลังงานต้องอย่างน้อยให้ผลกำไรที่เท่าเทียมหรือมากกว่าแบบอาคารทั่วๆไปจึงจะแรงจูงใจให้เจ้าของโครงการเลือกลงทุนในอาคารประหยัดพลังงาน

การศึกษานี้มีวัตถุประสงค์ที่ปรับปรุงแบบอาคารชุดพักอาศัยที่มีอยู่ทั่วไปเพื่อลดการใช้พลังงานภายในอาคารและเพื่อตรวจสอบว่าการปรับเปลี่ยนนั้นมีความเป็นไปได้ทางการเงิน การศึกษานี้ใช้แบบอาคารชุดพักอาศัยมาตรฐานที่มีอยู่ในตลาดเมืองไทย อาคารที่ใช้ศึกษามีความสูงที่น้อยกว่า 23 เมตร และมีพื้นที่ไม่เกิน 10,000 ตารางเมตร ส่วนแรกของวิทยานิพนธ์ตรวจสอบผลประโยชน์ที่ผู้ซื้อได้รับจากการประหยัดพลังงานหลังการปรับเปลี่ยนแบบคอนโดทั่วไปที่มีพื้นที่ 27 ตรม.ให้เป็นแบบประหัดพลังงาน สิ่งแรกคือลดความร้อนที่เข้าสู่อาคารผ่านเปลือกนอกอาคาร ภาระการทำความเย็นของแต่ละหน่วยจะคำนวณโดยใช้สูตร Q=U*A* CLTD สำหรับพื้นผิวอาคารภายนอก และ Q=U*A*ΔT สำหรับผนังภายใน จากนั้นจึงแปลงค่าพลังงานจากภาระการทำความเย็นเป็นค่าใช้จ่ายพลังงานของผู้ซื้อ ค่าใช้จ่ายที่ลดลงในการใช้พลังงานเป็นระยะเวลากว่า 10 ปีที่มีการคำนวณแล้วเป็นมูลค่าปัจจุบันสุทธิ (NPV) เพื่อตรวจสอบผลประโยชน์ของผู้ซื้อที่เป็นตัวเงิน ส่วนที่สองของการศึกษามีวัตถุประสงค์เพื่อหาความเป็นไปได้ทางการเงินของอาคารชุดพักอาศัยแบบประหยัดพลังงาน วิทยานิพนธ์นี้ได้ศึกษาความสามารถในการทำกำไรของโครงการอาคารชุดพักอาศัยทั่วไปและอาคารชุดพักอาศัยแบบประหยัดพลังงานเพื่อทำการเปรียบเทียบ

ภาระความร้อนของห้อง 27 ตรม.ในอาคารชุดพักอาศัย รวมถึงพื้นผนังภายนอกและใน กิจกรรมของมนุษย์ อุปกรณ์และเครื่องใช้ไฟฟ้าและอากาศที่แทรกซึมจากภายนอก ผลที่ได้พบว่าการใช้ไฟฟ้าสูงสุดของอาคารชุดพักอาศัยแบบทั่วไปคือ 27,707.91 btu / ft2°h โหลดสูงสุดของการออกแบบการประหยัดพลังงานเท่ากับ 11,067.63 btu / ft2°h อาคารแบบประหัดพลังงานช่วยประหยัดพลังงานได้ประมาณ 60% เจ้าของได้รับประโยชน์จากการลดค่าใช้จ่ายตั้งแต่ 4,000บาท ถึงมากสุด 16,741.50 บาทต่อปี ค่าใช้จ่ายในการก่อสร้างของแบบทั่วไปมีค่าที่ 433,994.14 บาท /ห้อง และ ห้องอาคารชุดพักอาศัยแบบประหยัดพลังงานมีค่าที่ 498,193.36 บาท/ห้อง ซึ่งแพงกว่าเดิม 15% โครงการอาคารชุดพักอาศัยแบบประหยัดพลังงานต้องเพิ่มราคาขายห้องจาก1.16 ล้านบาทเป็น 1.23 ล้านบาทเพื่อรักษาผลกำไรหลังหักภาษี (Net profit after tax) ของเจ้าของโครงการให้คงเดิม ผู้ซื้อห้องอาคารชุดพักอาศัยแบบประหยัดพลังงานจึงมีค่าใช้จ่ายที่เพิ่มขึ้น 70,000 บาท ซึ่งมีระยะเวลาคืนทุนสั้นสุด 4.2ปี ถึงนานสุด17.7 ปี โครงการอาคารชุดพักอาศัยแบบประหยัดพลังงานนั้นสามารถทำกำไรได้เท่าเทียมกับอาคารชุดพักอาศัยแบบทั่วไป สามารถลดค่าใช้จ่ายให้แก่ผู้ซื้อและผู้ขาย และช่วยให้ประเทศไทยเป็นมิตรกับสิ่งแวดล้อมมากยิ่งขึ้นโดยสามารถลดการปล่อยคาร์บอนไดออกไซด์ได้ถึง 207 ตันต่อวัน

ภาควิชา สถาปัตยกรรมศาสตร์ ลายมือชื่อนิสิต .....

สาขาวิชา สถาปัตยกรรม ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

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TITA CHINSOMBOON: Financial Feasibility of Energy-Saving Residential Condominium. ADVISOR: ASSOC. PROF. VORASUN BURANAKARN, Ph.D.{, pp.

Condominiums have shown steady growth in supply in Thailand. These buildings have high energy consumption, and with the world's energy crisis, it is important to make condominiums more energy efficient. However, the business side also requires due consideration. An energy efficient design must be at least as profitable as typical designs for project owners to have an incentive to invest.

The study aims to improve the typical design of a condominium to reduce energy use within the building, and to determine whether the modification is financially feasible. The study used a standard condominium design available in the Thai market that is less than 23 meters high and has an area of no more than 10,000 square meters as a case study. In the first part, the paper examines the energy-saving benefits gained from modifying the typical condominium design for 27 m^2 unit buyers. First, reduce heat entering the building through the outside building envelope. The cooling load of each unit is calculated using the formula Q=U*A*CLTD for external envelopes, and Q=U*A*ΔT for internal walls. Then the load is converted into energy expenses of buyers. The reduced expense on energy over a 10-year period is then calculated into net present value (NPV) to determine the buyer's benefit in monetary terms. The second part of the study aims to find the financial feasibility of an energy-efficient condominium. The study looked at the feasibility of a typical condominium and an energy-saving condominium. This part looks at the profitability of both the typical and energy-saving condominium projects for comparative study.

The thermal load of a 27m^2 unit includes the envelope, the floor, inner walls, regular human activity, equipment and appliances, and infiltration. The result found that the peak load of the typical design is 27,707.91 btu/ft2°h; the peak load of the energy-saving design is 11,067.63 btu/ft2°h. The design saves energy by approximately 60%. Owners gain the benefit of saved expenses from a minimum of 4,000 per year to 16,741.50 Baht per year at maximum. The construction cost of a typical design is 433,994.14 Baht/unit, and 498,193.36 Baht/unit for the energy-saving design which is 15% higher. Developers can have the same net profit after tax if price of the energy-saving design is increased to 1.23M Baht from the typical selling price at 1.16M Baht. Buyers must absorb the increased cost of 70,000 Baht, but the earning from decreased energy cost payback within a minimum of 4.2 to a maximum of 17.7 years. Energy-saving condominiums can be as profitable as the typical condominiums for developers, cost friendly for buyers, and help Thailand become more eco-friendly by reducing CO2 emission by 207 tons per day.

Department: Architecture Student's Signature .....
Field of Study: Architecture Advisor's Signature .....
Academic Year: 2014

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Chapter 1

Introduction

1.1 Background

The real estate market in Thailand is growing steadily, especially condominiums. The structures consume a high amount of energy, if they are built to be energy-efficient, it would greatly reduce the energy budget of Thailand. However, project owners care only for the turnover rate and the return on investment, while buyers care only for the location and price. As a result, condominiums are not designed to be energy efficient. Without due consideration to cooling load of building materials and design, the building can consume a lot of energy. Materials that are used typically do not insulate heat well, such as prefabricated concrete panels. Other design aspects that may look good but waste energy can include a floor-to-ceiling window. These factors add to the cooling load and the discomfort of occupants.

Figure 1-1 Cumulative Condominium Supply Bkk Colliers International Thailand Research.

The typical design of condominiums across Thailand follow a similar layout. The studio type is the most common, and smallest of the available varieties in the current condominium market. They are approximately 25-40 m^2 in size. The room is made up of 1 bedroom, 1 living area, 1 small kitchen and 1 bathroom. The floor plan usually form a long rectangle, with rooms on either side opening onto a long central corridor. One side of each unit would be connected to the external wall that transfers in a lot of heat. The other sides of the unit will either be connected to other rooms or the corridor.

Figure 1-2 Typical Condominium Room Plan.

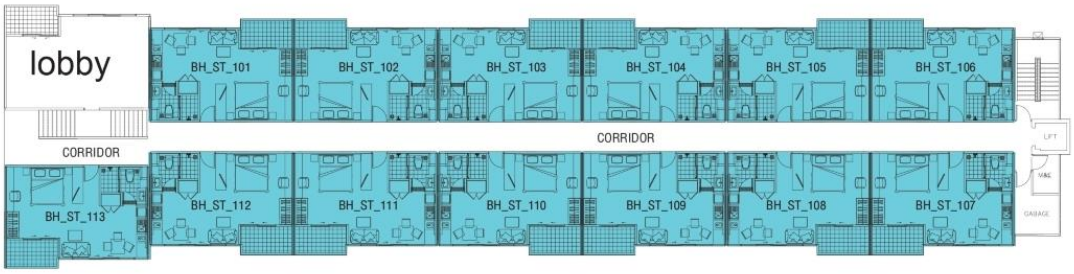

Figure 1-3 Typical Condominium Floor Plans.

Designing a condominium should take into consideration not only the investment costs but also the benefits for owners and the environment in general. Despite that, it is true only if the project owners and buyers find it financially feasible. If an energy-efficient condominium is a profitable venture, only then will there be more such projects.

1.2 Objective of the study

1. Evaluate benefits for buyers of energy-saving condominium.
2. Evaluate financial feasibility, and opportunities for developers.

1.3 Scope of the study

1. This study will case study a condominium building design that has a height not exceeding 23 m and is no bigger than 10,000 m^2.
2. Energy consumption of end users will study 27 m^2 units, which are the typical condominium unit size in the market.
3. Condominium case study will be unfurnished.
4. Condominium case study is located in the outer Bangkok area
5. Condominium case study is for middle to low income market.

1.4 Expected benefit of the study

1. Gain knowledge on the benefits of energy saving condominium units for buyers.
2. Condominium developers have information on how their project can be energy-saving and still be financially feasible.

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Chapter 2

Literature Review

2.1 Energy Crisis

The world today is consuming greater and greater amount of energy, increasing as high as five percent per year. As the lifestyles of humans change with the times, the energy-intensive living habits are taking a toll on the planet's resources and survival. Extreme climate changes and global warming is the thing of the present, and continue to become more severe as pollution builds up. One of the main causes is electricity generation using "unclean" fuels that release greenhouse gases into the atmosphere. Energy policies in many countries have instigated the increase of "green" or renewable energy to reduce the carbon footprint. However, this remedial solution may be inadequate in the long-run. The real problem –higher energy consumption – has not been resolved.

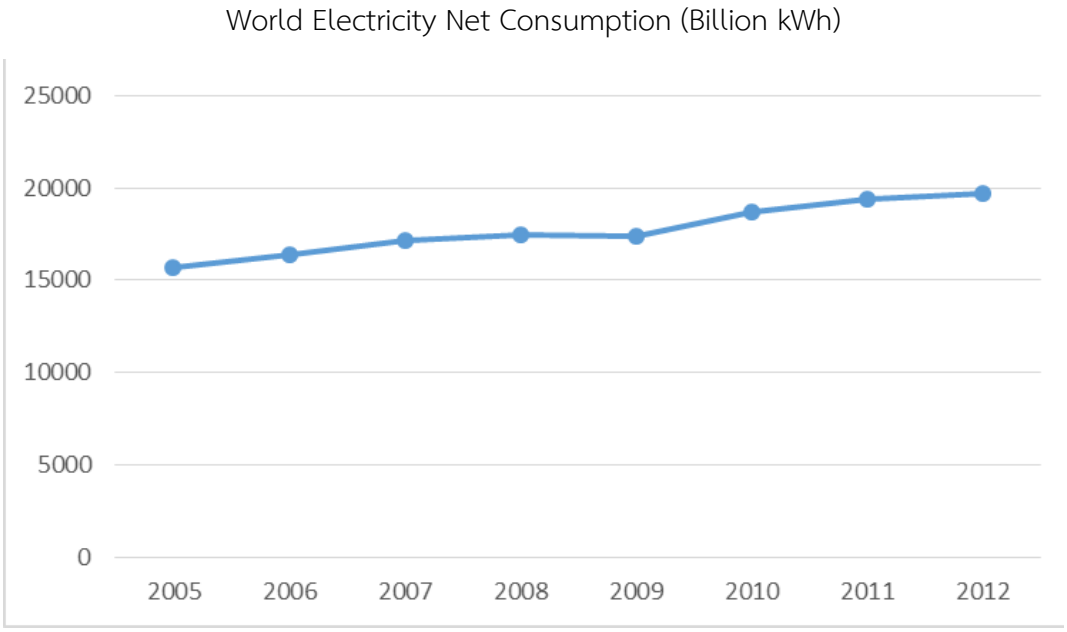

Figure 2-1 World Electricity Net Consumption (Billion kWh): U.S. Energy Information Administration 2015

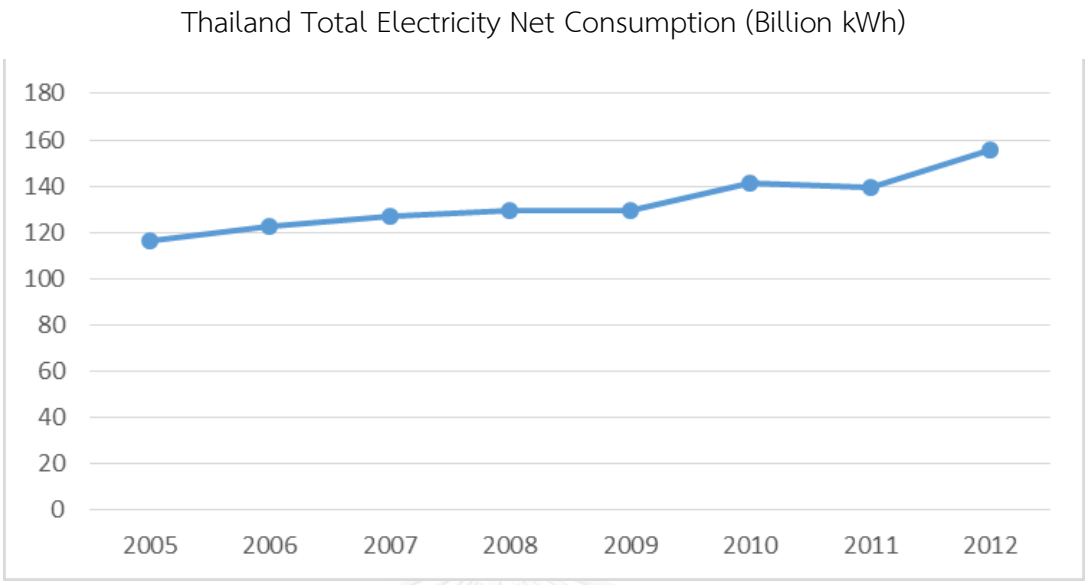

Figure 2-2 Thailand Total Electricity Net Consumption (Billion kWh): U.S. Energy Information Administration 2015

2.2 Energy Consumption and Architecture

Thailand, too, has seen a steady increase in the consumption of electricity. Electricity consumption within the residential sector in Thailand has risen over the years as the real estate market saw high growth. This makes up approximately twenty percent of total electricity consumption. It is necessary to help reduce the energy consumption from one of the significant causes.

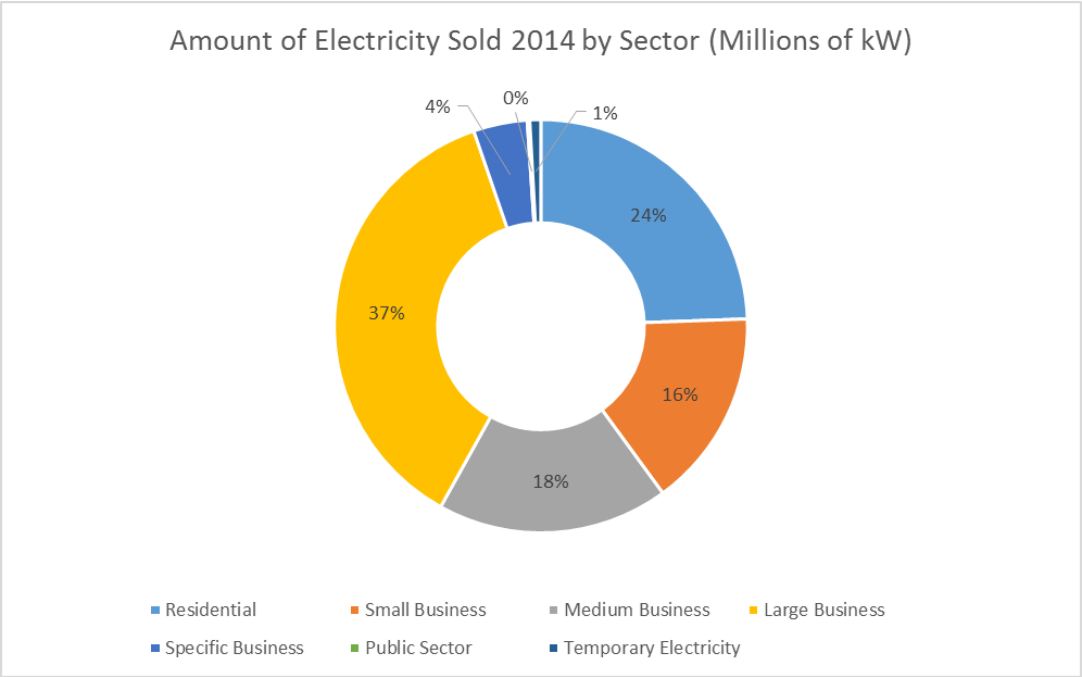

Figure 2-3 Amount of Electricity Sold in 2014 by sector (millions of kW)[1]

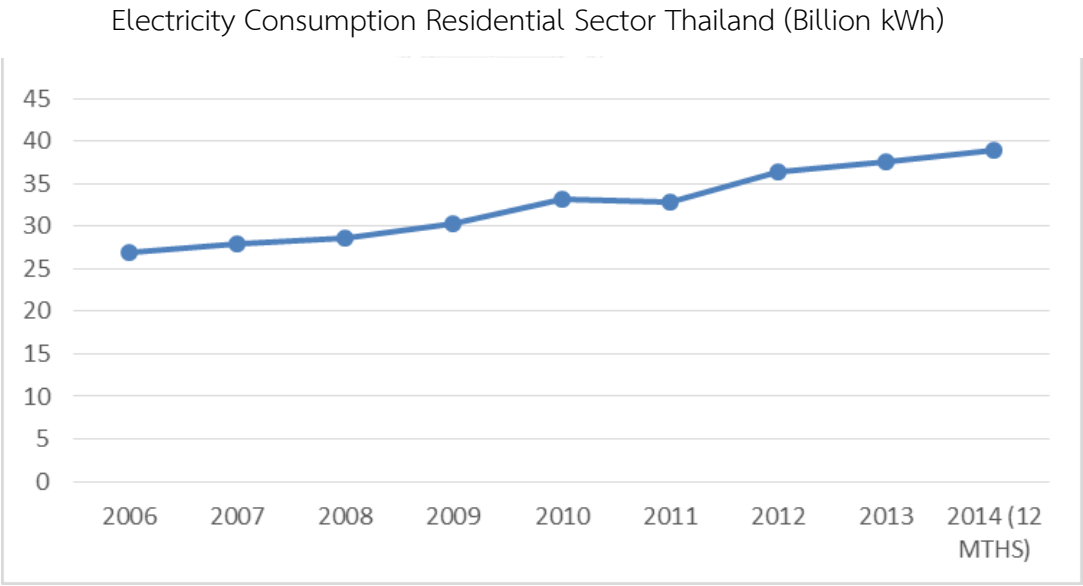

Figure 2-4 Electricity Consumption Residential Sector: [2]

Buildings can be energy-efficient if design, materials, and operation is suitable to the climate and region in which they are located. Thailand is a hot and humid country that requires design specifications that differ from colder country. Because the temperature is above the human comfort zone[3] most of the year, people have come

to rely heavily on air-conditioning, which takes up approximately 80 percent of total energy within a household. The problem is made worse when the building itself creates higher temperature.

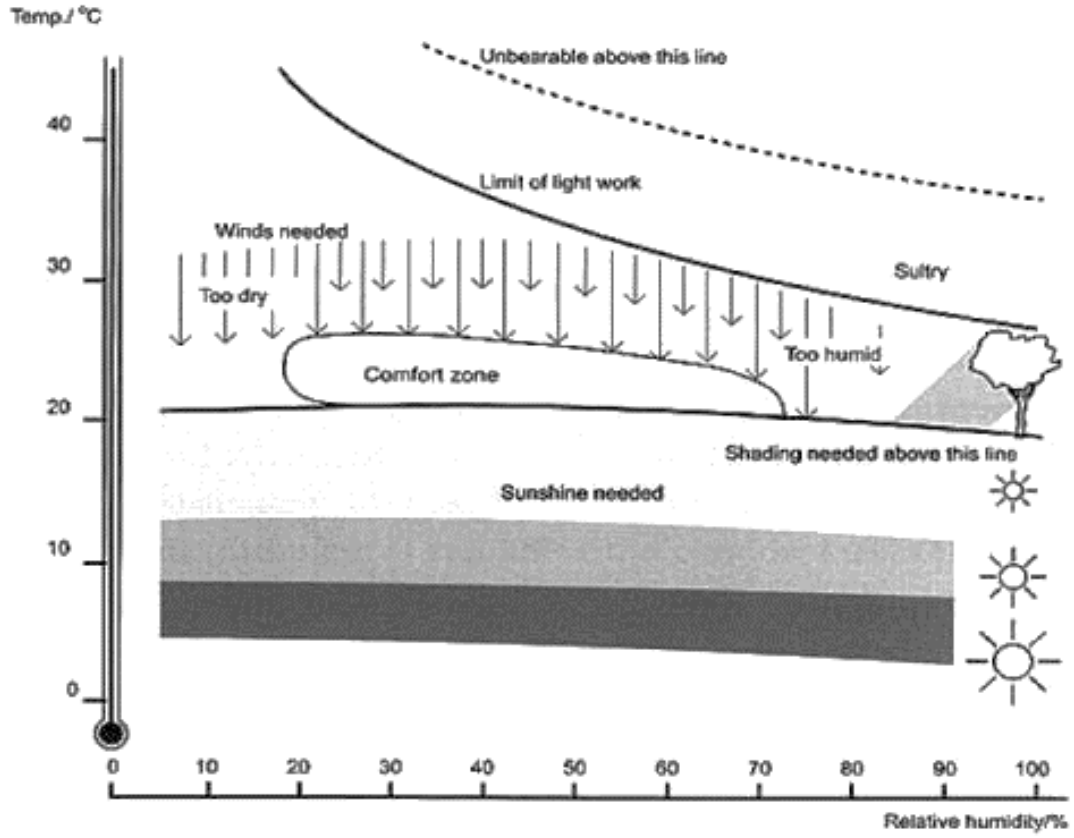

Figure 2-5 Bioclimatic chart representing comfort zone [3]

Buildings in Thailand mostly emulate the style of western architecture and are typically built with high mass materials that do not insulate heat or moisture very well. The worst trend for thermal comfort that came to Thailand is, however, the “glass house” trend, where floor-to-ceiling glass panels are installed as the building envelope. They are stylish, but the glass house effect creates a heavy thermal load that leads to heavy energy use for air-conditioning.

2.3 Energy Efficiency

Cooling Load is the amount of thermal energy that must be removed by the air-conditioning unit within a building. The types of energy can be divided into two categories: sensible and latent. "The sensible cooling load refers to the dry bulb temperature of the building and the latent cooling load refers to the wet bulb temperature of the building. In the summer, humidity influence in the selection of the HVAC equipment and the latent load as well as the sensible load must be calculated."[4]

Building Envelope -Minimizing energy consumption within a building starts with limiting heat flow through the envelope. The materials used should have high insulation properties that reduce heat transfer into the building. The indicator of a material is its R-value, or the heat resistance value,

2.4 Price of Electricity in Thailand

Table 2-1 Price of electricity in the year 2015 (Source: The Metropolitan Electricity Authority [1])

Residential Eectricity Price		Electricity price	Service fee
		Baht/kW	Baht/month
Less than 150 kW/month	kW number		8.19
First 5 kW	0-5	0	
Next 10 kW	6-15	1.3576	
Next 10 kW	16-25	1.5445	
Next 10 kW	26-35	1.7968	
Next 65 kW	36-100	2.18	
Next 50 kW	101-150	2.2734	
Next 250 kW	151-400	2.7781	
More than 400 kW up	from 401 on	2.978	

2.5 Low-rise Condominiums

Low-rise condominiums, or condominiums that are no higher than 23 meters and has an area of no more than 10,000 square meters, have grown in recent years. This is due to the relative ease in which permits can be obtained to construct this type of building. The administrative cost is considerably lower because 8-floor buildings do

not need to obtain an Environmental Impact Assessment (EIA) prior to construction. The fire codes are also more relaxed in small buildings.

2.6 Economic climate

In year 2014, Thailand experienced a bout of peaceful period where the government is not being actively opposed by the public and no major strikes or demonstrations were observed. The economy was going through a period of recovery. Amidst the government reform, the economic climate of Thailand saw moderate GDP growth at 1-1.7 percent for that year.

In 2015, the government attempts to boost the economy further, forming policies to increase spending. One of the major policies was to decrease interest rates to encourage consumer spending. Another notable movement, is the legislation on land and housing tax that is being revised. However, the decision is not yet concrete in the first half of the year. This led to some sluggishness in the real estate market and investors and buyers wait on the results.

2.7 Financial Feasibility of Real Estate Projects

Before a developer invests in a real estate project, it is necessary to gauge its feasibility. This is achieved through sales projection, cost projection and financial formulas.

Key factors of a project includes:

- Cash flow (CF) = Cash Received from Issuing Stock or Debt - Cash Paid as Dividends and Re-Acquisition of Debt/Stock
- Cost = the amount (of money) required to purchase goods or services
- Cost of Goods Sold (COGS) = cost of goods sold, excluding interest and tax
- Gross Profit = Total Revenue – Total Cost
- Gross Profit Margin = a ratio of profitability calculated as net income divided by revenues, or net profits divided by sales. It measures how much out of every dollar of sales a company actually keeps in earnings.

$$= \frac{\text{Revenue - Cost of Goods Sold}}{\text{Revenue}}$$

- Earnings Before Interest and Tax (EBIT) = Revenue - Cost of Goods Sold - Operating Expenses

-Net Profit after Tax (NPAT) = the final profit figure after all expenses have been accounted

Key indicators of feasibility:

- Payback Period (PP) = the number of years it takes for a company to recover its original investment in a project, when net cash flow equals zero. In the calculation of the payback period, the cash flows of the project must first be estimated.

- Free Cash flow for the Firm (FCFF) = a measure of financial performance that expresses the net amount of cash that is generated for the firm, consisting of expenses, taxes and changes in net working capital and investments.

- Internal Rate of Return (IRR) = the discount rate that makes the net present value of all cash flows of a project equal to zero. Higher IRRs makes a project more attractive.

- Net Present Value (NPV) = the difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyze the profitability of an investment or project.

*Some definitions were obtained from www.investopedia.com[5]

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2.8 Carbon Credit

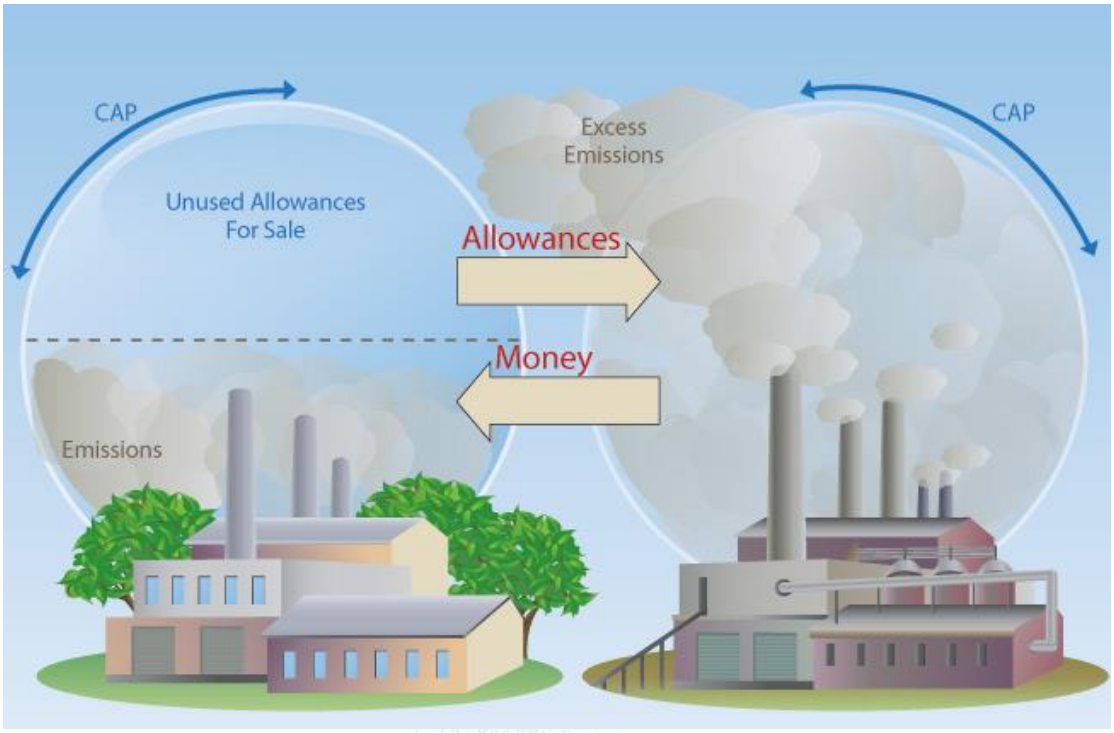


Figure 2-6 Carbon credit concept (Source: Thailand Greenhouse Gas Management Organization (TGO)[6]

The concept of emission trading is simple. A firm starts with a certain amount of greenhouse gases emission allowance, if it does not use all the allowance, then it can trade what it hasn't used to other companies for money. This provides incentive for firms to become cleaner in their production, as cleaner means more money. The carbon credit comes in the form of tradable permit or certificate that represents the right to emit 1 ton of CO_2.

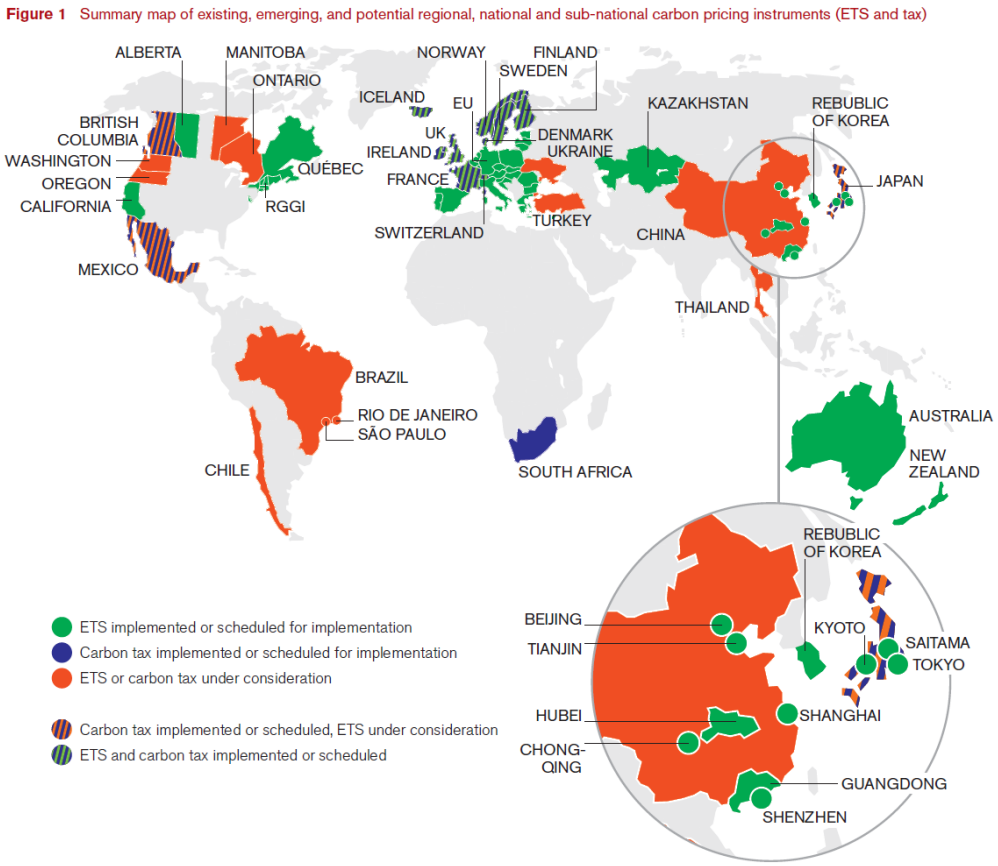


Figure 2-7 Summary of existing, emerging and potential regional, national and sub-national carbon pricing instruments (ETS and tax)[7]

Internationally, carbon credit is implemented largely in North America, Europe and Japan. Europe has its European Union Emission Trading Scheme (EU ETS) was the first emission trading platform that was created in response to the 1997 UN Kyoto Protocol. London founded the Carbon Trade Exchange since year 2009, and it has gained more popularity in the years that follow. Price of the EU ETS is 7.355 Euro per tCO_2.

Currently Thailand has no legislation on this matter, but there is a Voluntary Emission trading Scheme (V-ETS) in place. Its main function is to measure, report and verify to develop a carbon market in Thailand. The program is in its trial period and V-ETS permits are now being sold.

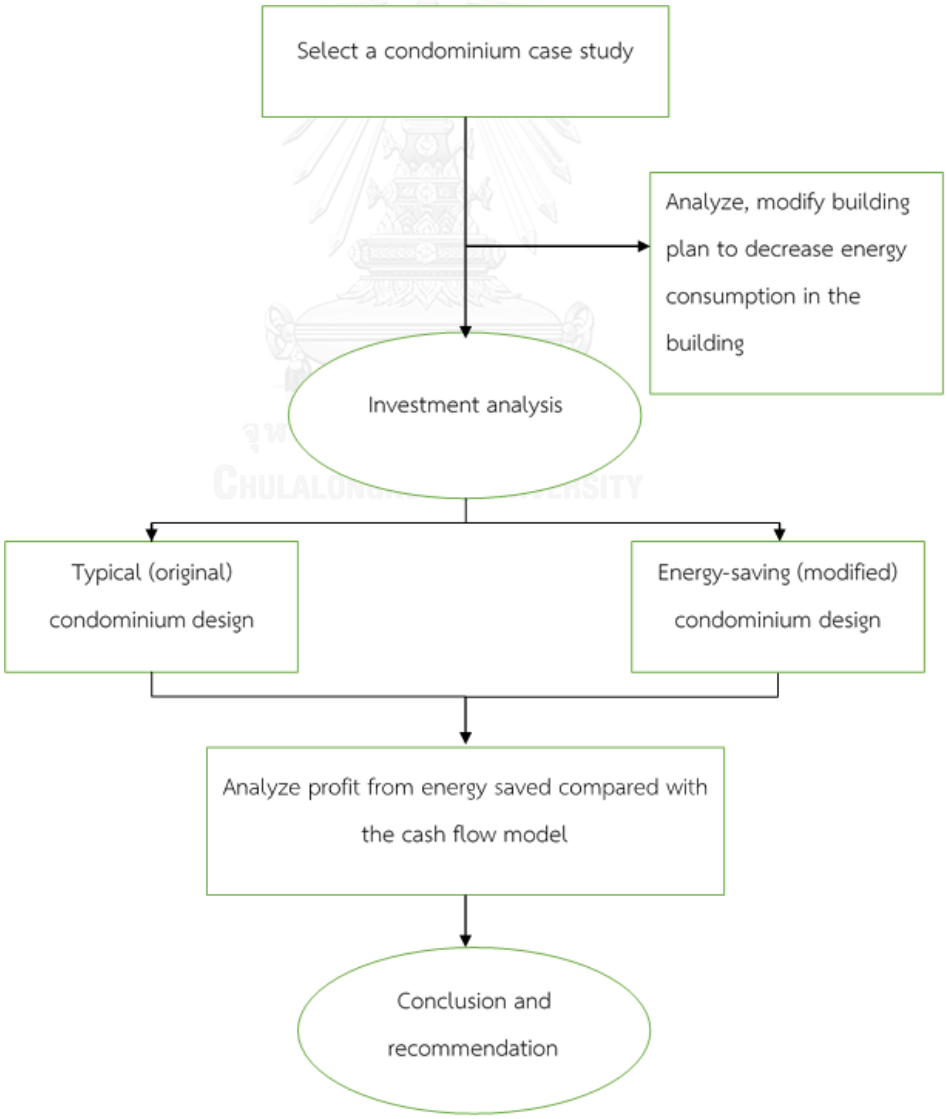
Chapter 3
Methodology

3.1 Overview

This paper aims to measure the benefits that an energy-saving condominium will generate for:

- The buyers or the consumers who will own the condominium unit.
- The developers who will invest and build the condominium project.

The methodology process is as shown below:



3.2 Selecting a condominium case study

To do a fair analysis of an energy-saving condominium, the study will use room and floor plans that are available in the market. Data of condominiums are gathered from real estate websites, selecting low-rise condominiums that are:

- Located within the Bangkok area
- Building is no taller than 23 m
- Building has total area of no more than 10,000 m^2

Results found that the average condominium has the following properties:

- The shape of the condominium is a long rectangular shape with rooms positioned on either side of a central corridor.
- The building has 8 floors
- Rooms are typically 27 m^2 and has one external wall while the other walls are internal.

The chosen condominium plan is a completed condominium that belongs to a large well-known real estate developer in Thailand. The company is famous for its numerous condominium projects for middle-income market group. This firm is considered one of the leading force in the market. Projects are completed swiftly, its low-rise condominium projects are completed in less than a year, using plans that are based on an established model.

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Figure 3-1 Typical room plans.

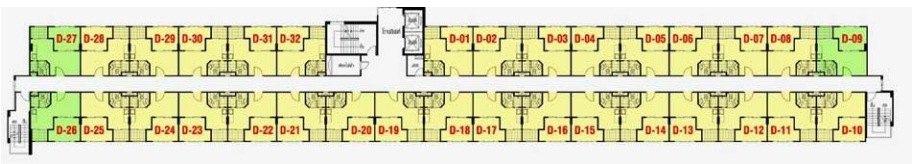

Figure 3-2 Typical floor plan of a condominium.

3.3 Analyze and modify building plan to reduce energy consumption within a building

To find out the how much a condominium building affects energy consumption, the paper looks at the consumption of a unit owner. To do that the study calculates the thermal load of all factors that affects the consumption of electricity through the use of the air-conditioning system in a unit:

- Building envelope: roof and wall materials
- Fenestration: glass type and window size
- Air infiltration
- Lighting
- Human and equipment

The thermal load of a typical 27 m^2 unit is calculated for the peak month in the unit will face south and is not directly located under the roof of the condominium to realistically represent the majority of the units. The design temperature within the human comfort zone [3] is set at 25°C. For this type of unit a typical number of residence would be 2 adults and 1 child, who live a regular pattern where they are go out during the day and return in the evening. Equipment and appliances within the unit includes a computer, a Wi-Fi signal router, air-conditioner, microwave, electric kettle, kitchen hood, refrigerator, washing machine and television.

This part of the paper uses a program created by Laoimjan, S.[8], which referenced its source from ASHRAE, while the data on air temperature is adjusted for Bangkok, using historic data from year 2013. The program uses the ASHRAE formulae. Details on the calculation program, the formulas and figures used in the calculation program can be found in the Appendix.

1. External wall: Heat transfer through the envelope will affect load of the unit, and as a result affects energy-use. Load will be measured using the formula: Q = U*A*CLTD [9]

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i. Q = thermal load (Btu/h*ft2*°F)

ii. U = wall/window materials' u-value = 1/∑R or the heat transfer rate

iii. A = surface area of wall

iv. CLTD = Cooling Load Temperature Difference

2. Internal walls: Walls between rooms and walls connected to the corridor, using the formula: Q = U*A*ΔT [9]

i. Q = thermal load (Btu/h*ft2*°F)

ii. U = wall materials' u-value = 1/∑R or the heat transfer rate

iii. A = surface area of material

iv. ΔT = difference between inside temperature and outside temperature

3. Infiltration: ACH = (CFM x 60)/ building volume

4. Appliances, lighting, users and operation is calculated based on the watts of energy the person or object generates.

Once energy consumption for the typical building is calculated, the results are used to modify the condominium plan into an energy-saving plan. Modification dealt primarily with the materials rather than the esthetic aspect of the condominium; shape, size and orientation of the building will be kept the same.

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3.4 Investment analysis

This part financially compares the typical condominium with energy-saving condominium plans.

3.4.1 Condominium owner's financial benefit gained from an energy-saving condominium through lower energy expenditure

Calculate the benefits condominium owners gain from energy-saving condominium units, the study looks at how much money the owners can save on energy expenses over a 10-year period.

To convert energy saved into how much owners save on expenses, project the costs over a 10-year period then convert into its Net Present Value (NPV) using the following formula:

$$\mathrm{NPV}(i,N) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

Where:

t = the time period of cash flow

i = the discount rate, or the rate of inflation at 2.5% per year as indicated by the Bank of Thailand in 1Q 2015.

R_t = the net cash flow

The current price of electricity is on average 3 Baht per kWh (or 1000 W/h). Using the following formula as the base in the calculation:

Total load x 1/Coefficient of Performance x Price of Electricity

Coefficient of performance (COP) is the amount of heating or cooling in proportion to the energy consumed by a particular air-conditioning unit. Higher COP means more heating/cooling and less energy consumed; this is desirable as it means lower operating costs. The typical 1/COP is 0.5, which is the standard for air-conditioning units sold in Thailand.

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3.4.2 Condominium developer's financial benefit gained from an energy-saving condominium

Analyze financial feasibility of the energy-efficient condominium for investors through comparative study, measuring the profitability of the project owner and the construction costs.

- All cases are set to analyze a 5-year analysis
- Project sale figures at 80% sales

- Prices are set to yield net profit that is equal to the existing market condition, thus reflecting the minimum condition that developers will accept to invest in energy-saving condominium projects.

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Chapter 4
Results

4.1 Overview

This part of the paper will examine the effects of energy-saving condominium on buyers and developers. The model condominium selected is located in the outer Bangkok area. The project is located on a 7-Rai piece of land valued at an estimated 140 million Baht (12,500 Baht per m^2) by the Department of Lands (DOL). There are 4 condominium towers and 1024 units within the project, all abiding the low-rise criteria.

The study will first look at heat load that affects energy consumption within a unit to identify significant variables that can be modified to reduce the load. Then, the study will evaluate the effect of energy-saving condominium units on energy consumption and expenditure of owners. Evaluating on a micro level first is done deliberately, so that the results from the first part can lead to the necessary modification in the condominium.

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Next, the study will evaluate the benefits of energy-saving condominiums for developers. The financial feasibility of typical condominiums is already established. The developers would not invest in such projects if it were unprofitable to do so. The financial evaluation of the typical model is for comparative evaluation. Comparing the typical model with the energy-saving model will produce a clearer picture.

4.2 Effect on Buyers

4.2.1 Buyer's Energy Consumption

Energy Consumption is a part of everyday life. The requirement for energy of a modern family is increasing due to technology oriented lifestyle. The concern of a

home owner that comes every month will include the electricity bill. Therefore, it is in the best interest of the homeowners that energy costs drop.

The thermal load of a typical 27 m^2 unit is calculated for the peak month in the unit will face south and is not directly located under the roof of the condominium to realistically represent the majority of the units. The design temperature within the human comfort zone[3] is set at 25°C. For this type of unit a typical number of residence would be 2 adults and 1 child, who live a regular pattern where they are go out during the day and return in the evening. Equipment and appliances within the unit includes a computer, a Wi-Fi signal router, air-conditioner, microwave, electric kettle, kitchen hood, refrigerator, washing machine, television,

4.2.1.1 Typical Condominium Unit Energy consumption

Table 4-1 Thermal resistance of materials within a typical condominium unit.

R-Value (Btu/h*ft2*°F)					
	Concrete Wall Outside	Concrete Wall Inside	Windows Outside	Concrete Ceiling inside	Concrete Floor inside
Outside air film	0.25	n/a	0.25	n/a	n/a
Material	0.32	0.24	0.03	0.32	0.32
Inside air film	0.68	1.36	0.68	0.92	0.61
Total R value	1.25	1.60	0.96	1.24	0.93
U value =1/ΣR	**0.80**	**0.63**	**1.04**	**0.81**	**1.08**

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The table shows the Thermal R-value of building envelope and inside wall materials. The typical materials used for the external walls are basically precast concrete with no additional insulation, and 6mm glass windows. These materials are chosen for their availability, quickness and familiarity in construction, and relatively low price. Concrete walls outside and the ceilings are 4 inches thick, while inside walls are 3 inches. The windows are 6 mm clear float glass.

Table 4-2 Peak thermal load summary of a typical condominium unit.

Thermal source	Specification	Amount	unit	Total Load per room (Btu/h◦ft2°F)	Load per m2 (Btu/h°F)	Load per m2 (W)
Ceiling	4" Concrete	27	m2	2589.48	95.91	28.11
Glass	Clear Float 6mm	5.76	m2	2640.15	97.78	28.66
External Wall	4" Concrete	8.27	m2	3009.21	59.81	17.53
Internal Wall(s)	4" Concrete	41.86	m2	6195.48	105.12	30.81
Floor	4" Concrete	27	m2	3452.64	127.83	37.46
Door	1.5" Wood	1.4	m2	120.96	3.46	1.01
Human	3 person	3	ppl	1170.00	33.43	9.80
Electric equip.	Full set of appliances	2000	watt	6824.00	252.74	74.07
Lighting	incandescent light @5 bulbs	500	watt	1706.00	63.19	18.52
	Total thermal load			**27,707.91**	**839.26**	**245.97**

The Department of Alternative Energy Development and Efficiency (DEDE) indicated that a residence must have an OTTV of less than 45 W/m^2. This means that the average thermal transfer of the envelope of the building, such as windows and external walls, per one square meter should not exceed 45 W/m^2. The calculation shows that the unit's OTTV is 28.66+17.53 = 46.19W/m^2. The figure shoe that the regular condominium does not adhere to the criterion set by the DEDE. From the total peak load, the required size of the air-conditioning unit for a 27 m^2 room would be approximately 2.31 tons (27,707.91btu /12000btu). This can however still feel inadequate if the Mean Radiant Temperature (MRT) of the surroundings is high, which will make occupants feel warmer than the actual air-temperature.

Looking at the table above, the main cause of the thermal load that can be eliminated without negatively affecting the owner's living standard is to eliminate the heat load from the building envelopes. Once the building envelopes are insulated, the thermal load of inner walls will be eliminated, as the whole building acts as one insulated unit.

4.2.1.2 Energy-saving Condominium Unit

Table 4-3 Thermal resistance of materials within an energy-saving condominium unit.

R-Value (Btu/h*ft2*°F)					
	Concrete Wall Outside	Concrete Wall Inside	Windows Outside	Concrete Ceiling inside	Concrete Floor inside
Outside air film	0.25	n/a	0.25	n/a	n/a
Material	0.32	0.24	2.00	0.32	0.32
Insulation Molded expanded polystyrene (EPS)	12.00				
Inside air film	0.68	1.36	0.68	0.92	0.61
Total R value	13.25	1.60	2.93	1.24	0.93
U value =1/ΣR	**0.08**	**0.63**	**0.34**	**0.81**	**1.08**

Table 4-4 Peak Thermal load summary of an energy-saving condominium unit.

Thermal source	**Specification**	**Amount**	**unit**	**Total Load per room (Btu/h◦ft2°F)**	**Load per m2 (Btu/h°F)**	**Load per m2 (W)**
Ceiling	4" Concrete	27	m2			
Glass	Insulated Glass	5.76	m2	2539.84	71.45	20.94
External Wall	4" Concrete with insulation	8.27	m2	192.59	5.92	1.73
Internal Wall(s)	4" Concrete	41.86	m2			
Floor	4" Concrete	27	m2			
Door	1.5" Wood	1.40	m2			
Human (normal)	3 person family	3	ppl	1170.00	33.43	9.80
Electric equip.	Full set of appliances	2000	watt	6824.00	252.74	74.07
Lighting	LEDs light @5 bulbs	100	watt	341.20	12.64	3.70
	Total thermal load			**11067.63**	**376.18**	**110.25**

The R-value material specifications for the energy-saving model is significantly higher due to insulation with 3-inch EPS foam. Heat insulation is present on the outer wall to prevent thermal transfer from outside. The windows are double-pane insulated glass. It is only necessary to insulate the envelope to prevent heat transfer from outside, treating the whole building as one unit. The internal load is relatively unchanged, except for the use of a more efficient light bulbs that uses less energy.

The energy-saving model reduces thermal transfer by approximately 60%. The OTTV of the energy-saving model is only 20.94+1.73 = 22.67 W/m^2. The required air-conditioning unit is 0.92 tons (11,067.63 btu /12,000 btu)

4.2.2 Energy Cost Saving for Owners

To determine the benefits the unit owner will receive living in an energy condominium rather than a typical one will look at how much energy is saved and how much less money will be spent. The calculation will include the cost of electricity that is used for air-conditioning calculated based on an 8-hour use of the unit.
The current price of electricity is on average 3 Baht per kWh (or 1000 W/h). Energy cost can be calculated using the formula:

(Load (kWh) x Area (m^2) x 1/COP)/1000 x 3 Baht.

Where 1/COP = 0.5; which is the normal performance of air-conditioning units sold in stores in Thailand.

The peak cost of the Typical unit:

(0.245*8 hours)*27*0.5*3 = 79.38 Baht/day

79.38*30 =2,381.4 Baht/month

2,381.4 *12 =28,576 Baht/year

The average cost of the Typical unit:
The 8-hour general building energy use is estimated at 420 kWh/m^2/yr or 1.15 kWh/m^2[10].

1.15*27*0.5*3=46.60 Baht/day

46.60*30 =1,398 Baht/month

1,398*12 =16,776 Baht/year

The peak cost of Energy-saving unit:

(0.11*8hours)*27*0.5*3 =35.64 Baht/day

35.64*30 = 1,069.20 Baht/month

1069.20*12 =12,830.4 Baht/year

Simple payback –

Table 4-5 Money saved from less electricity consumption by owners.

	Typical -Peak (Bath)	Typical -Average (Baht)	Energy-saving (Baht)
Year 1	28,576.00	16,776.00	12,830.00
Year 2	28,576.00	16,776.00	12,830.00
Year 3	28,576.00	16,776.00	12,830.00
Year 4	28,576.00	16,776.00	12,830.00
Year 5	28,576.00	16,776.00	12,830.00
Year 6	28,576.00	16,776.00	12,830.00
Year 7	28,576.00	16,776.00	12,830.00
Year 8	28,576.00	16,776.00	12,830.00
Year 9	28,576.00	16,776.00	12,830.00
Year 10	28,576.00	16,776.00	12,830.00
Total	285,760.00	167,760.00	128,300.00

The buyer can save on electricity expenses at the maximum of 28,576-12,830 =16,196 Baht/ year, and a minimum of 16,776-12,830 = 3,946 Baht/year.

Net Present Value of Payback

The projected energy costs over a 10-year period and convert into its Net Present Value (NPV) using the following formula:

$$\mathrm{NPV}(i,N) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

Where:

t = the time period of cash flow

i = the discount rate, or the rate of inflation at 2.5% per year as indicated by the Bank of Thailand in 1Q 2015.

R_t = the net cash flow

The current price of electricity is on average 3 Baht per kWh (or 1000 W/h).

Table 4-6 NPV of money saved from less electricity consumption by owners.

	Typical -Peak (Bath)	Typical -Average (Baht)	Energy-saving (Baht)
Inflation	2.5%	2.5%	2.5%
Year 1	28,576.00	16,776.00	12,830.00
Year 2	30,004.80	17,614.80	13,471.50
Year 3	31,433.60	18,453.60	14,113.00
Year 4	32,862.40	19,292.40	14,754.50
Year 5	34,291.20	20,131.20	15,396.00
Year 6	35,720.00	20,970.00	16,037.50
Year 7	37,148.80	21,808.80	16,679.00
Year 8	38,577.60	22,647.60	17,320.50
Year 9	40,006.40	23,486.40	17,962.00
Year 10	41,435.20	24,325.20	18,603.50
NPV	**303,826.43**	**178,366.19**	**136,411.43**

- The calculation assumed that the inflation rate is 2.5% per year while the price of electricity grow by 1% each year. The buyer can save on electricity expenses at the

maximum of 303,826.43-136,411.43 =167,415 Baht/10 years, and a minimum of 178,366.19-136,411.43 = 41,954.76 Baht/ 10 years. Or 16,741.50-4,195.48 Baht/year.

-

4.3 Effect on Developers

4.3.1 Financial Feasibility

The financial feasibility analysis looks at whether a project is a worthwhile investment. It studies the viability, which is when revenue exceeds cost. This part examine financial feasibility of the energy-efficient condominium through comparative study, measuring the profitability of the project owner.

Condominium project outline:

1) Location: Outer Bangkok area
2) Land area: 7-Rai or 11,200 m^2
3) Land cost (estimate): 140M Baht (12,500 Baht per m^2)
4) Number of buildings: 4
5) Total units for sale: 1,024 units
6) Sellable Area: 27,648 m^2
7) Area per room: 27 m^2
8) Debt portion: Financing the model is based on the same available loan given by banks in the year 2015, which is 60% of construction cost: 185M Baht
9) Equity injection is assumed to be financed by the developer: 123M Baht
10) Minimum Lending Rate (MLR): 6.75%

Sales Conditions are:

1) Average selling price per unit: 1.16M Baht
2) Reservation & contract payment 4%: 46,440 Baht
3) Down payment 11%: 5,321 Baht
4) Transfer payment 85%: 986,850 Baht
5) The study assumes that the maximum sale would be 80% of total saleable units.

4.3.2 Construction Costs

The main concern of a developer is cost. The estimate for an 8-15 story residence given buy the Thai Appraisal Foundation is between 13,000 - 21,000 Baht per m^2. However, this estimate can be biased as other building types other than condominiums are included. Therefore, this paper will use data obtained from a well-known condominium developer in Thailand. The data obtained from developers reflects the actual competitive cost structure that is achieved through comprehensive and standardized construction plan. Applying an established construction process allows them to build new projects in different locations quickly and cost-effectively.

The study compares 2 cases of the condominiums:

- Typical Model: The typical model uses the standardized cost and price of developers in the condominium market.
- Energy-saving Model: Modifies the Typical Model, all is consistent with the Typical, changing the cost according to the change in materials in part 4.2.

The industry's leaders have consistent cost ratio for all of their project. The data was calculated using three sets of Bill of Quantities (BOQ) of one of the major real estate developers in Thailand. The costs are summarized in the following table. The cost per square meter is an estimate. The table above takes the total cost of each item divide by the sellable area. At 11,010 Baht per m^2, the cost for industry leader is about 47% lower than the highest typical estimate, and approximately 15% lower than the lowest average estimate given by the Thai Appraisal Foundation.

Table 4-7 Construction costs of the typical condominium.

Item	Cost per m2 (Baht)	Percent
Contruction Preparation	600.00	5%
Structure	3,000.00	27%
Surface works	740.00	7%
Walls and wall surface works	2,200.00	20%
Ceiling	290.00	3%
Roof	190.00	2%
Door-windows	1,300.00	12%
Bathroom Fittings and equipments	600.00	5%
Miscellaneous	60.00	1%
Electrical and communication systems	1,800.00	16%
Compressed air and ventilation systems	160.00	1%
Preliminary	70.00	1%
Total	11,010.00	100%

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4.3.3 Energy-saving Modifications

The energy-saving model only modifies by adding insulation to the typical model. The design is otherwise unchanged. The following modifications were made:

Roof top insulation

- Insulate with sprayed polyurethane foam, with the thickness of 3 inches.
- Price of 3-inch insulation is 920 Baht per m^2
- Total roof area of the project is 11.9 m2 * 88.4 m2 * 4 buildings = 4,207.84 m^2
- Total cost of roof insulation = 4,207.84 m^2 * 920 Baht = 3,871,212.80 Baht

Walls insulation

- Insulate with Exterior Insulation Finishing System (EIFS) foam panels consisting of EPS foam with the thickness of 3 inches.
- Price of 3-inch insulation is 1500 Baht per m^2
- Total wall area of the project is (22 m^2 * 11.9 m^2 *2) * (22 m^2* 88.4 m^2*2) * 4 buildings = 17,652.8 m^2
- Total cost of wall insulation = 17,652.8 m^2 * 1,500 Baht = 26,479,200 Baht

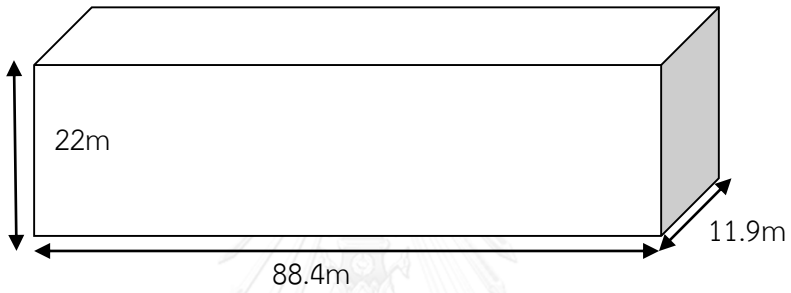

Figure 4-1 Building measurements

Windows Insulation

- Insulated windows with uPVC
- Price of insulation is 6,000 Baht per m2
- Total glass area of the project is 1.8m * 3.2m * 32 rooms * 8 floors *4 buildings =5898.24 m^2
- Total cost of window insulation is 35,389,440 Baht

Total additional cost of energy-saving condominium = 3,871,212.80 + 26,479,200 + 35,389,440 =65,739,852.80 Baht

As demonstrated, the energy-saving condominium becomes more expensive to construct. The majority of increased costs come from the walls and windows; wall requires added insulation, and windows are more expensive from higher quality glass and more panes that are needed to be made into insulated windows.

Table 4-8 Rough costs comparison.

	Typical	Energy-saving
Land	140M Baht	140M Baht
Construction	304.41M Baht	304.41M Baht
Insulation	-	65.74M Baht
Total Cost	444.41M Baht	510.15M Baht
Cost per 27m^2 unit	433,994.14 Baht	498,193.36 Baht
Selling Price	1.16M Baht	1.23M Baht

The energy-saving condominium costs around 14.8% more than the typical condominium, increasing from 444.41M Baht to 510.15M Baht. It is considerably higher than the typical model because of the added insulation cost of 65.74M Baht. The roof of the buildings are insulated with sprayed Polyurethane, and EIFS foam panels are installed on the external surface of the building to prevent heat from entering the building. The costs of insulated windows are also much higher as twice the number of glass panes is required, and more expensive frames.

Cost per unit increases from 433,994.14 Baht to 498,193.36 Baht. Selling price of the condominium increase from 1.16M Baht to 1.23M Baht, or from 43000 Baht/m^2 to 45710Baht/m^2.

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4.3.4 Profitability: Comparison

Profitability is the perhaps the most important aspect among numerous factors that influence the decision of a firm before investing in a project. There will three comparison cases in this part:

1. Typical condominium: the base case, where profitability reflects the norm of the market.

2. Energy-saving condominium (selling price unchanged): interim case, the condominium have been modified to be energy-saving with higher costs, but the selling price is the same as the typical model.

3. Energy-saving condominium: the condominium have been modified to be energy-saving with higher costs, but the selling price is the higher than the typical model to enable the firm to gain equal amount of net profit.

Sales and Cash flow

Sales pattern is kept constant in both models. The study disregard the marketing effect of increased price to evaluate the simple effect change in price on profitability.

Table 4-9 Condominium Units Sales Projection.

Monthly sales													
Items	Year 1												
	Jan 14	Feb 14	Mar 14	Apr 14	May 14	Jun 14	Jul 14	Aug 14	Sep 14	Oct 14	Nov 14	Dec 14	2014
No. of units sold		10	10	10	10	10	10	20	20	20	20	20	160
Accumulated no. of units sold		10	20	30	40	50	60	80	100	120	140	160	160
	Year 2												
	Jan 15	Feb 15	Mar 15	Apr 15	May 15	Jun 15	Jul 15	Aug 15	Sep 15	Oct 15	Nov 15	Dec 15	2015
	20	20	20	20	20	20	20	20	20	20	20	20	240
	180	200	220	240	260	280	300	320	340	360	380	400	400
	Year 3												
	Jan 16	Feb 16	Mar 16	Apr 16	May 16	Jun 16	Jul 16	Aug 16	Sep 16	Oct 16	Nov 16	Dec 16	2016
	20	20	20	20	20	20	20	20	20	20	20	20	240
	420	440	460	480	500	520	540	560	580	600	620	640	640
	Year 4												
	Jan 17	Feb 17	Mar 17	Apr 17	May 17	Jun 17	Jul 17	Aug 17	Sep 17	Oct 17	Nov 17	Dec 17	2017
	10	10	10	10	10	10	10	10	10	10	10	10	120
	650	660	670	680	690	700	710	720	730	740	750	760	760
	Year 5												
	Jan 18	Feb 18	Mar 18	Apr 18	May 18	Jun 18	Jul 18	Aug 18	Sep 18	Oct 18	Nov 18	Dec 18	2018
	10	10	10	10	10	10	0	0	0	0	0	0	60
	770	780	790	800	810	820	820	820	820	820	820	820	820

Year 1 - The construction begins, equity is drawn for construction costs while pre-sale starts. However, the sales figure is still low, acquiring only reservation and contract payment, and later some down payment. Net cash f low is negative.

Year 2-4 - Construction is completed in the middle of the Year 2. Accumulated sales increase steadily. Cash flow now includes the Transfer payment after the construction is completed. This greatly increased the cash inflow. Assuming that the

typical model is a famous condominium chain that has a good brand image, sales volume was adjusted to be selling at 80% of total rooms within 4 years.

Year 5 – The majority of rooms sold have already been transferred to private owners. Cash flow decrease.

Table 4-10 Typical Condominium Cash flow.

Yearly cashflows							
Items	Units	Total	Year 1 2014	Year 2 2015	Year 3 2016	Year 4 2017	Year 5 2018
Cash inflows							
Loan for land acquisition	THB million	0.00	0.00	0.00	0.00	0.00	0.00
Loan for construction	THB million	185.00	0.00	0.00	185.00	0.00	0.00
Equity injection	THB million	123.00	123.00	0.00	0.00	0.00	0.00
Sales of units	THB million	896.69	1.86	241.10	294.84	259.40	99.50
Other income	THB million	0.00	0.00	0.00	0.00	0.00	0.00
Total cash inflows	THB million	1,204.69	124.86	241.10	479.84	259.40	99.50
Cash outflows							
Land acquisition	THB million	140.00	140.00	0.00	0.00	0.00	0.00
Construction & other costs	THB million	318.69	34.41	113.21	167.53	3.54	0.00
Selling, General & Administrative Expense	THB million	62.53	2.17	19.09	14.67	20.32	6.27
Interest expenses	THB million	5.35	0.00	0.00	5.13	0.22	0.00
Loan repayment	THB million	185.00	0.00	0.00	139.32	45.68	0.00
Tax payment	THB million	103.58	0.00	28.31	35.29	27.36	12.62
Total cash outflows	THB million	815.15	176.59	160.61	361.94	97.13	18.89
Net cash flows	THB million	389.55	(51.73)	80.49	117.90	162.27	80.61
Ending cash	THB million	389.55	(51.73)	28.77	146.66	308.94	389.55

Table 4-11 Energy-saving Condominium Cash flow (selling price unchanged).

Items	Units	Total	Year 1 2014	Year 2 2015	Year 3 2016	Year 4 2017	Year 5 2018
Cash inflows							
Loan for land acquisition	THB million	0.00	0.00	0.00	0.00	0.00	0.00
Loan for construction	THB million	224.41	0.00	0.00	224.41	0.00	0.00
Equity injection	THB million	149.61	149.61	0.00	0.00	0.00	0.00
Sales of units	THB million	896.69	1.86	241.10	294.84	259.40	99.50
Other income	THB million	0.00	0.00	0.00	0.00	0.00	0.00
Total cash inflows	THB million	1,270.71	151.47	241.10	519.25	259.40	99.50
Cash outflows							
Land acquisition	THB million	140.00	140.00	0.00	0.00	0.00	0.00
Construction & other costs	THB million	386.66	41.75	137.35	203.26	4.30	0.00
Selling, General & Administrative Expense	THB million	62.53	2.17	19.09	14.67	20.32	6.27
Interest expenses	THB million	7.98	0.00	0.00	6.97	1.01	0.00
Loan repayment	THB million	224.41	0.00	0.00	139.32	85.09	0.00
Tax payment	THB million	92.27	0.00	25.14	31.57	24.30	11.27
Total cash outflows	THB million	913.85	183.92	181.58	395.78	135.03	17.54
Net cash flows	THB million	356.86	(32.46)	59.52	123.46	124.37	81.96
Ending cash	THB million	356.86	(32.46)	27.07	150.53	274.90	356.86

Table 4-12 Energy-saving Condominium Cash flow.

Items	Units	Total	Year 1	Year 2	Year 3	Year 4	Year 5
			2014	2015	2016	2017	2018
Cash inflows							
Loan for land acquisition	THB million	0.00	0.00	0.00	0.00	0.00	0.00
Loan for construction	THB million	224.41	0.00	0.00	224.41	0.00	0.00
Equity injection	THB million	149.61	149.61	0.00	0.00	0.00	0.00
Sales of units	THB million	953.21	1.97	256.30	313.42	275.75	105.77
Other income	THB million	0.00	0.00	0.00	0.00	0.00	0.00
Total cash inflows	THB million	1,327.23	151.58	256.30	537.83	275.75	105.77
Cash outflows							
Land acquisition	THB million	140.00	140.00	0.00	0.00	0.00	0.00
Construction & other costs	THB million	386.66	41.75	137.35	203.26	4.30	0.00
Selling, General & Administrative Expense	THB million	66.47	2.31	20.29	15.59	21.60	6.66
Interest expenses	THB million	7.43	0.00	0.00	6.75	0.68	0.00
Loan repayment	THB million	224.41	0.00	0.00	148.10	76.31	0.00
Tax payment	THB million	103.57	0.00	28.26	35.36	27.32	12.63
Total cash outflows	THB million	928.53	184.06	185.90	409.06	130.21	19.30
Net cash flows	THB million	398.69	(32.48)	70.39	128.77	145.54	86.47
Ending cash	THB million	398.69	(32.48)	37.91	166.68	312.22	398.69

The total cash inflows for the Typical, Energy-saving (selling price unchanged), and Energy-saving (selling Price increased) are 1,204.69M Baht, 1,270.71M Baht, and 1,327.23M Baht, respectively. The inflows are affected by the injected loan, equity, and sales. Because the Typical model costs the least and has a lower price, the inflows is lowest out of the three cases. Similarly, the cash outflows for Typical, Energy-saving (selling price unchanged), and Energy-saving (selling Price increased) are 815.15M Baht, 913.85M Baht and 928.53M Baht, respectively. The Energy-saving model have higher costs which makes the outflow higher.

Profit and Loss

This part looks at the bottom line of the project. The net profit after tax (NPAT) value of the project is a good indicator of the attractiveness of the project. This aims to look at how the energy-saving condominium compares to the typical model.

Table 4-13 Typical condominium Profit and Loss Statement.

Items	Units	Total	Year 1	Year 2	Year 3	Year 4	Year 5
			2014	2015	2016	2017	2018
Revenue							
Revenue from sales	THB million	952.02	0.00	267.03	313.47	257.74	113.78
Other income	THB million	0.00	0.00	0.00	0.00	0.00	0.00
Total revenue	THB million	952.02	0.00	267.03	313.47	257.74	113.78
Cost of goods sold							
Land & land development cost	THB million	112.11	0.00	31.45	36.91	30.35	13.40
Construction & other costs	THB million	255.20	0.00	71.58	84.03	69.09	30.50
Capitalized interest	THB million	4.28	0.00	1.20	1.41	1.16	0.51
Total cost of goods sold	THB million	371.60	0.00	104.23	122.35	100.60	44.41
Gross profit margin	THB million	580.42	0.00	162.80	191.12	157.14	69.37
Selling, General & Administrative Expenses	THB million	62.53	2.17	19.09	14.67	20.32	6.27
Total expenses	THB million	62.53	2.17	19.09	14.67	20.32	6.27
EBIT	THB million	517.90	(2.17)	143.71	176.45	136.82	63.10
Interest expenses	THB million	0.00				0.00	0.00
EBT	THB million	517.90	(2.17)	143.71	176.45	136.82	63.10
Corporate income tax	THB million	103.58	0.00	28.31	35.29	27.36	12.62
NPAT	THB million	414.32	(2.17)	115.40	141.16	109.45	50.48

Table 4-14 Energy-saving condominium Profit and Loss Statement (Selling Price unchanged).

Items	Units	Total	Year 1	Year 2	Year 3	Year 4	Year 5
			2014	2015	2016	2017	2018
Revenue							
Revenue from sales	THB million	952.02	0.00	267.03	313.47	257.74	113.78
Other income	THB million	0.00	0.00	0.00	0.00	0.00	0.00
Total revenue	THB million	952.02	0.00	267.03	313.47	257.74	113.78
Cost of goods sold							
Land & land development cost	THB million	112.11	0.00	31.45	36.91	30.35	13.40
Construction & other costs	THB million	309.63	0.00	86.85	101.95	83.83	37.00
Capitalized interest	THB million	6.39	0.00	1.79	2.10	1.73	0.76
Total cost of goods sold	THB million	428.13	0.00	120.08	140.97	115.91	51.17
Gross profit margin	THB million	523.89	0.00	146.95	172.50	141.83	62.61
Selling, General & Administrative Expenses	THB million	62.53	2.17	19.09	14.67	20.32	6.27
Total expenses	THB million	62.53	2.17	19.09	14.67	20.32	6.27
EBIT	THB million	461.37	(2.17)	127.85	157.83	121.51	56.34
Interest expenses	THB million	0.00				0.00	0.00
EBT	THB million	461.37	(2.17)	127.85	157.83	121.51	56.34
Corporate income tax	THB million	92.27	0.00	25.14	31.57	24.30	11.27
NPAT	THB million	369.09	(2.17)	102.72	126.27	97.21	45.07

Table 4-15 Energy-saving condominium Profit and Loss Statement (Selling Price increased).

Items	Units	Total	Year 1	Year 2	Year 3	Year 4	Year 5
			2014	2015	2016	2017	2018
Revenue							
Revenue from sales	THB million	1,012.02	0.00	283.86	333.23	273.99	120.95
Other income	THB million	0.00	0.00	0.00	0.00	0.00	0.00
Total revenue	THB million	1,012.02	0.00	283.86	333.23	273.99	120.95
Cost of goods sold							
Land & land development cost	THB million	112.11	0.00	31.45	36.91	30.35	13.40
Construction & other costs	THB million	309.63	0.00	86.85	101.95	83.83	37.00
Capitalized interest	THB million	5.95	0.00	1.67	1.96	1.61	0.71
Total cost of goods sold	THB million	427.68	0.00	119.96	140.82	115.79	51.11
Gross profit margin	THB million	584.34	0.00	163.90	192.40	158.20	69.84
Selling, General & Administrative Expenses	THB million	66.47	2.31	20.29	15.59	21.60	6.66
Total expenses	THB million	66.47	2.31	20.29	15.59	21.60	6.66
EBIT	THB million	517.87	(2.31)	143.61	176.81	136.60	63.17
Interest expenses	THB million	0.00				0.00	0.00
EBT	THB million	517.87	(2.31)	143.61	176.81	136.60	63.17
Corporate income tax	THB million	103.57	0.00	28.26	35.36	27.32	12.63
NPAT	THB million	414.30	(2.31)	115.35	141.45	109.28	50.54

The gross profit for the Typical, Energy-saving (selling price unchanged), and Energy-saving (selling Price increased) are 580.42M Baht, 523.89M Baht, 584.34M Baht, respectively. Gross profit is essentially Revenue-Cost of Goods Sold, which is why gross profit for the Energy-saving (selling price unchanged) case is the lowest because it takes in to account the COGS that is higher for the energy-saving condominium but the selling price is the same as the Typical. The Gross profit of the Typical and Energy-saving (selling Price increased) cases are almost identical because the price of the energy-saving condominium was increased in proportion to the increase in cost. For that same reason, the NPATs of the Typical is 414.32M Baht and Energy-saving (selling Price increased) is 414.30M Baht, which are almost equal. The desirability are equal for both models.

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Project Feasibility

Table 4-16 Typical condominium Feasibility.

Project feasibility			2014	2015	2016	2017	2018
FCFF	THB million		-174.73	80.49	77.35	208.17	80.61
Accumulated FCFF	THB million		-174.73	-94.23	-16.89	191.28	271.89
			3.00	12.00	12.00	0.97	
WACC	%		12.00%				
NPV Project	THB million		158.20				
IRR Project	%		46.49%				
Payback period	years		27.97	months	2.33	years	

Table 4-17 Energy-saving condominium (selling price unchanged).

Project feasibility			2014	2015	2016	2017	2018
FCFF	THB million		-182.07	59.52	45.34	210.48	81.96
Accumulated FCFF	THB million		-182.07	-122.54	-77.20	133.28	215.24
			3.00	12.00	12.00	4.40	
WACC	%		12.00%				
NPV Project	THB million		109.13				
IRR Project	%		34.15%				
Payback period	years		31.40	months	2.62	years	

Table 4-18 Energy-saving condominium (selling price increased).

Project feasibility			2014	2015	2016	2017	2018
FCFF	THB million		-182.09	70.39	59.20	222.53	86.47
Accumulated FCFF	THB million		-182.09	-111.69	-52.49	170.04	256.51
			3.00	12.00	12.00	2.83	
WACC	%		12.00%				
NPV Project	THB million		141.31				
IRR Project	%		40.64%				
Payback period	years		29.83	months	2.49	years	

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Chapter 5
Conclusion and Discussion

Conclusion, Discussion and Further Suggestions

5.1 Conclusion

Energy-saving condominiums is the way of the future. As land becomes increasingly expensive, especially in the urban areas where prices go up by 10-15% yearly, there is a need for a more efficient use of space. Condominiums are the solution, its useful space is maximized in a given piece of land. Developers can make profit to make up for the cost of their land. However, the attention of developers are usually concentrated on the margin and how to sell faster. This profit-centric thinking has neglected the effects of buildings on the consumers and the environment, negatively affecting our society as a whole. This is why it is necessary to make condominiums energy-saving and financially feasible.

The benefits, tangible and intangible far outweighs the fiscal drawback. On the consumer side, they receive the most apparent benefits: lower energy expenses. The NPV data shows that owners can reduce expenses from 4,195.48 Baht per year to 16,741.50 Baht per year. This fiscal reduction goes toward a more efficient and less costly life style. Another valuable trait for the owner is that an energy-saving condominium gives a better quality of life. As ambient temperature is lower in the energy-saving model, occupants lives in an environment that is closer to the human comfort zone. The lower mean radiant temperature (MRT) of the surroundings also have health benefits for the aging process of the human skin.

Energy-saving condominiums have a higher cost of construction, being around 6% more expensive. For developers, they can add the extra expense into the price to let the buyers absorb the cost. Despite the higher price, energy-saving can act as a

premium in marketing. Also, the lower cost on energy of the buyers can be accounted into the increased price range. In this study, the price of the typical condominium is set at 1.16M Baht. If the Energy-saving model retain the same selling price then the profit margin would drop, which would discourage developers from investing in this type of project. However, forcing the developers to absorb the cost is unnecessary. Energy-saving condominium unit selling price can be set at 1.23M Baht, a relatively small increase, the net profit would remain the same. In both models. The higher price is possible if the firm market the fact that buyers can save 3,946 to 16,741.50 Baht per year. Simple payback period is (1.23M -1.16M)/3,946 = 17.7years at the maximum and (1.23M -1.16M)/16,196 = 4.3 years at the minimum. The NPV payback for the additional cost for buyers would be (1.23M -1.16M)/4195.68 = 16.7 years at the maximum and (1.23M -1.16M)/16741.50 = 4.2 years at the minimum.

Additionally, the buyer will have to install the A/C unit at the time he moves into the room, which costs 2 Baht per btu. The typical unit will need to purchase at least an A/C unit that is 2.3 tons to adequately air-condition the room during peak period, spending a total of about 55,200 Baht. Whereas the owner of the energy-saving unit can just buy the 24,000 Baht A/C (or 1 ton). This means the buyer of the energy-saving condominium saves 31,200 Bath further. This can shorten the payback period even more. So after accounting the cost of the A/C unit, the payback period would be:

1.23M-1.16M -31,200=38,800 Baht

Simple payback

Minimum 38,800/16,196 =2.4 years; Maximum 38,800/3,946= 9.8 years

NPV payback

Minimum 38,800/16,741.50 =2.3 years; Maximum 38,800/4,195.48= 9.2 years

Still, developers in the Thai market today is still hesitant to invest more to help save energy, thinking that the consumption of energy by the owners are not their concern. The study found, however, that condominium can be energy-saving and still be equally profitable. The added cost of estimated 15% is made up by the increase

in price. The energy-saving condominium's gross profit drops because the COGS increased, but the NPAT is still the same as the regular case, which is really the most important fiscal factor for an investment. The former price of 43,000Baht/m^2 is raised to only 47,510 Baht/m^2 for the developer to gain equal profit. This is still below the average market price of 50,000-75,000 Baht/m^2 for condominiums in the suburban Bangkok areas. "The average price of new condominium units launched in the Bangkok suburbs in 3Q 2014 is approximately THB75,000 psm, an increase of around 20% from the prior quarter."[11]. In terms of sales, the price effect on the sale value should be minimal as the increased price is relatively lower than the average market selling price.

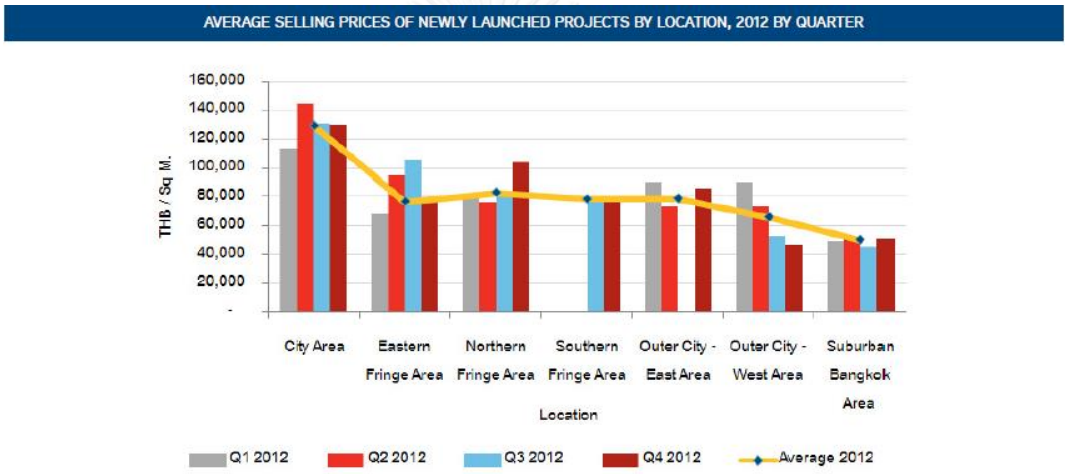

Figure 5-1 Average selling price of Condominium units 2012 by quarter (source: Collier's International Thailand Research).

The effect of selling price on monthly installments paid by the buyers is also minimal. For the typical condominium, the buyers have to pay 11% installments at 5,321 Baht per month for 24 months. The Energy-saving condominium's installment increase only by 319 Baht to around 5,640 Baht per month ((1.23M*11%)÷24payments). However, the developer can keep the installment amount the same and add the increase to the payment at the transfer date. The decision of buyers is influenced by the short-term loss, paying a smaller amounts in the beginning will make the sale more attractive.

Furthermore, the firm may think that they get nothing if they build an energy-saving condominium; that the best result would be to gain equal profit as the typical condominium. However, that is not strictly true. The developer will have to manage the condominium buildings. The administration will have an office there, and will benefit from low operating costs. Also, during the transfer period, sales area and show rooms will be within the building operating during the peak time, which is the day-time. The costs of operating these offices will be greatly reduced. Finally, the developers can hypothetically benefit from carbon credit trading as a supplementary income. Calculations can be found in the following part.

5.2 Limitations

It should be noted, however, that in reality the energy-saving condominium project's feasibility also depends on factors other than just the fiscal aspect. Location is the number one reason a buyer will consider a project, hence it is the key concern for any real estate project; the right location will determine sales. Marketing and product placement also plays a role in how a new product is received. Furthermore, the profit of the developers can also be gained through increased share prices, the energy-saving factor of a condominium can raise buyer's confidence. Though this study has looked at only the physical costs of the energy-saving condominium, the effects of energy-saving condominium on consumer's confidence and the stock price is another area that should be examined in the future.

For the society as a whole, benefit is received in the form of reduced energy budget. The residential sector accounts for at least 20% of the entire electricity consumption. As condominiums market is growing stronger, they will consume greater and greater amount of energy. For a better economy and society, energy-saving should become a requirement in building construction, as many other countries, such as Singapore and Japan, has already established.

5.3 Discussion

5.3.1Carbon credit calculation

In the previous part, the cost of being environmentally friendly is absorbed by the buyers, while the developers takes the risk of lower sales through increasing the selling price. Hypothetically, the developers can gain additional revenue through selling their carbon credits.

Assumption:

- 80% occupation in the condominium the total units occupied would be 820 units.
- Electricity consumption is calculated using 8-hour Air-conditioning operation time within a home.
- Carbon credit European Union Allowance (EUAs) is priced at 281.33 Baht (7.355*38.25 Euro) per tCO_2 (TGO, 2014)
- Carbon Emission per unit of electricity is 0.575 kg-CO_2/kWh (EPPO,2015)
- 1/COP = 0.5
- 1,000 kg-CO2 = 1 tCO2
- 1,000Wh = 1kWh

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Energy consumption of the typical condominium project

The typical condominium unit consumes

= 245.97 W * 27m2 * 1/COP * 8h = 26,564.768Wh = 26.56 kWh/day

Consumption of the whole project

= 26.56 kWh/day * 820 units

=21,779.2 kWh/day

CO2 Emission per day

= 21,779.2 kWh/day * 0.575

=12,523.04kg-CO2/day

=12.52 tCO2/day

Convert Carbon credit to Baht

=12.52*281.33 Baht

=3,523.11 Baht/day

=105,693.21 Baht/month

=1,268,318.46 Baht/year

Energy consumption of the energy-saving condominium project

The energy-saving condominium unit consumes

= 110.25 W * 27m2 * 1/COP * 8h = 11,907Wh =11.91 kWh/day

Consumption of the whole project

= 11.91kWh/day * 820 units

=9,766.2kWh/day

CO2 Emission per day

= 9,766.2 kWh/day * 0.575

=5,615.57 kg-CO2/day

=5.62 tCO2/day

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Convert Carbon credit to Baht

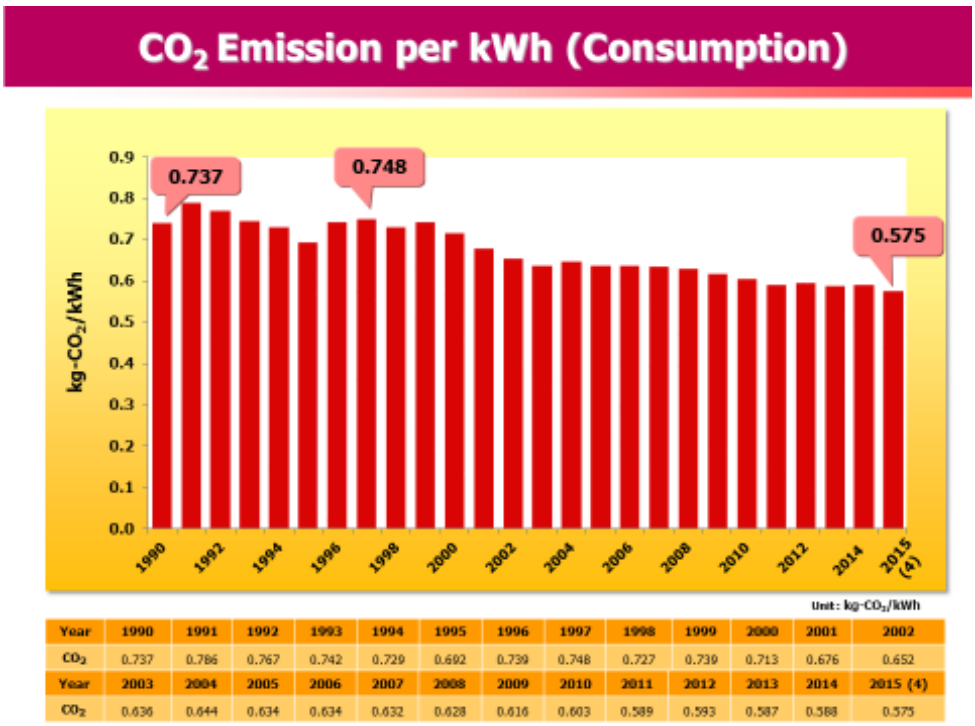
=5.62*281.33 Baht

=1,581.07 Baht/day

=47,432.24 Baht/month

=569,186.86Baht/year

If the developer build an energy-saving condominium project instead of the typical model, the developer can profit from selling carbon credits at 1,268,318.46 – 569,186.86Baht =699,131.60 Baht per year.



Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CO_2	0.737	0.786	0.767	0.742	0.729	0.692	0.739	0.748	0.727	0.739	0.713	0.676	0.652
Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015 (4)
CO_2	0.636	0.644	0.634	0.634	0.632	0.628	0.616	0.603	0.589	0.593	0.587	0.588	0.575

Figure 5-2 CO_2 Emission per kWh consumed (Source: EPPO).

5.3.2 Effect on Thailand's Energy Budget

Thailand would also benefit from more energy-saving condominiums. Every year, approximately 50,000 condominium units are launched in the market. This means more energy consumption from the sector.

Table 5-1 Energy consumption by percentage of new Energy-saving condominium units

Percentage	Energy Consumption gWh/yr
100%	434.61
75%	467.70
50%	500.80
25%	533.90
10%	553.76
0%	567.00

If 100% of new condominiums are energy-saving then the energy consumption is 434.61 gWh/year, compared to 567 gWh/year if none of the new condominium units are energy-saving. Energy can be save at the maximum 132.39 gWh/year. The reduction in consumption will reduce CO_2 emission by 207 tons per day.

5.4 Suggestions

- Thailand should develop Emission Trading further to offer incentive for firms to decrease GHG emissions.
- Thailand should pass building codes that require new buildings to be more energy-saving.
- Further study on the effect of price on marketing of energy-saving condominium will offer this topic a more comprehensive result.

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Table 5-2 Summary of Benefits gained from energy-saving condominiums.

Buyers	- Buyers have a better living standard and wellbeing from lower ambient temperature. - Lower energy costs by estimated 4,000-16,700 Baht per year. - Lower initial investment in buying the air-conditioning unit saving about 31,200 Baht.
Developers	- Better brand image through being "green" while still retaining the same net profit after tax. - Perform corporate social responsibility (CSR) through selling better products. - Expenses for the public areas is greatly reduced. - Hypothetical extra revenue from carbon credits sold, earning estimated 699,131.60 Baht per year.
Other Businesses	- Businesses selling products related to heat insulation experience growth.
Thailand	- More jobs created in the business sector that produces insulation. - Thermal waste is reduced. - Electricity consumption would drop by about 132.39 gWh/year if all new condominium units launched are energy-saving. - CO_2 emission would drop by 207 tons per day if all new condominium units launched are energy-saving.

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APPENDIX

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Carbon Credit Price

ตลาดคาร์บอนรายสัปดาห์

(21- 26 ธันวาคม 2557)

วันที่	ราคา EUAs แบบส่งมอบทันที (ยูโร/ตัน)	ราคาสัญญาซื้อขาย EUAs ล่วงหน้าสำหรับส่งมอบในเดือนธันวาคม 2015 (ยูโร/ตัน)	ราคา CERs แบบส่งมอบทันที (ยูโร/ตัน)	ราคาสัญญาซื้อขาย CERs ล่วงหน้าสำหรับส่งมอบในเดือนธันวาคม 2015 (ยูโร/ตัน)
24 ธ.ค. 2014	7.355 (ปริมาณ 0 ตัน)	7.460 (ปริมาณ 3,048,000 ตัน)	0.545 (ปริมาณ 0 ตัน)	0.540 (ปริมาณ 0 ตัน)
24 พ.ย. 2014	7.050 (ปริมาณ 70,000 ตัน)	7.160 (ปริมาณ 6,387,000 ตัน)	0.080 (ปริมาณ 0 ตัน)	0.530 (ปริมาณ 35,000 ตัน)

ที่มา: https://direct.argusmedia.com , http://data.theice.com/

หมายเหตุ: ราคาที่แสดงในตารางเป็นราคาปิดของวัน และ ปริมาณการซื้อขายในตารางเป็นปริมาณซื้อขายตลาดทั้งวันในตลาด

Figure a - 1 Carbon Market weekly price December 2014.

List of Appliances within a home

Computer -150W

Tea kettle -100W

Television-150W

Refrigerator- 50W

Washing machine- 100W

Microwave-500W

Hairdyer-50W

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Insulation

Figure a - 2 Roof-top insulation: Polyurethane foam is sprayed onto the rooftop.

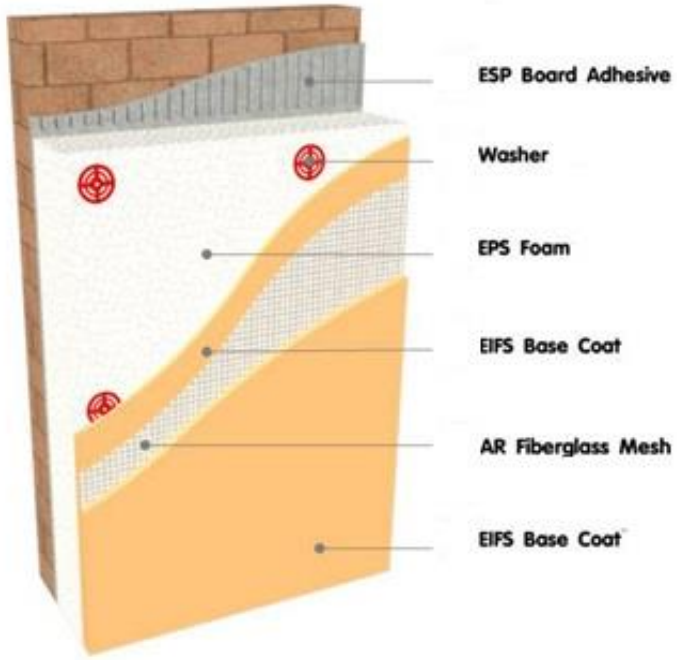

Figure a - 3 Wall Insulation EPS foam.

Figure a - 4 Insulated Glass.

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