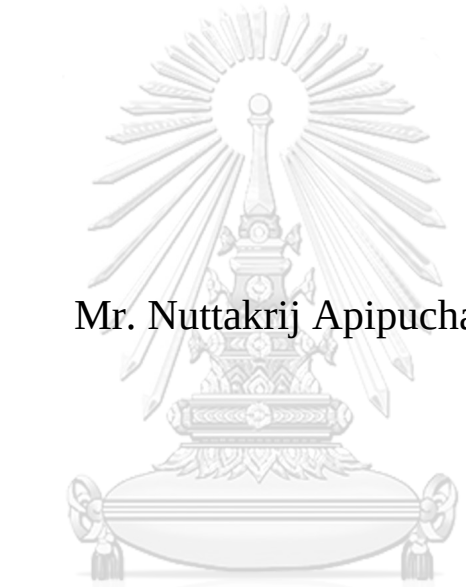
PURCHASING BEHAVIOR OF LED LIGHTBULBS OF THAI CONSUMERS

Mr. Nuttakrij Apipuchayakul



A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Environment, Development and Sustainability
Inter-Department of Environment,Development and Sustainability
GRADUATE SCHOOL
Chulalongkorn University
Academic Year 2019

พฤติกรรมการซื้อหลอดไฟแอลอีดีของผู้บริโภคชาวไทย

นายณัทกฤช อภิภูชยะกุล

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรดุษฎีบัณฑิต
สาขาวิชาสิ่งแวดล้อม การพัฒนา และความยั่งยืน สหสาขาวิชาสิ่งแวดล้อม การพัฒนาและความยั่งยืน
บัณฑิตวิทยาลัย จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2562

Thesis Title	PURCHASING BEHAVIOR OF LED LIGHTBULBS OF THAI CONSUMERS
By	Mr. Nuttakrij Apipuchayakul
Field of Study	Environment, Development and Sustainability
Thesis Advisor	Dr. SUJITRA VASSANADUMRONGDEE

Accepted by the GRADUATE SCHOOL, Chulalongkorn University in Partial Fulfillment of the Requirement for the Doctor of Philosophy

..... Dean of the GRADUATE SCHOOL
(Associate Professor THUMNOON NHUJAK)

DISSERTATION COMMITTEE

..... Chairman
(Associate Professor DAWAN WIWATTANADATE)
..... Thesis Advisor
(Dr. SUJITRA VASSANADUMRONGDEE)
..... Examiner
(Assistant Professor Suthirat Kittipongvises)
..... Examiner
(Assistant Professor KANITTHA TAMBUNLERTCHAI)

ณัทกฤช อภิภูชยะกุล : พฤติกรรมการซื้อหลอดไฟแอลอีดีของผู้บริโภคชาวไทย. (PURCHASING BEHAVIOR OF LED LIGHTBULBS OF THAI CONSUMERS) อ.ที่ปรึกษาหลัก : ดร.สุจิตรา วาสนาดำรงดี

การใช้ไฟฟ้าในภาคครัวเรือนเป็นอุปสงค์ที่สำคัญของการผลิตและใช้พลังงานทั่วโลก ปัจจุบัน มีการพัฒนาเทคโนโลยีของหลอดไฟฟ้าให้แสงสว่างที่มีประสิทธิภาพมากขึ้น คือ หลอดไฟแอลอีดี (Light-Emitting Diode, LED) ที่ช่วยประหยัดการใช้พลังงานไฟฟ้ามากกว่าหลอดไส้และหลอดคอมแพคต์ฟลูออเรสเซนต์ (Compact Fluorescent Lamp, CFL) ซึ่งหากทุกครัวเรือนได้เปลี่ยนไปใช้หลอด LED ก็จะช่วยให้ประเทศประหยัดพลังงานได้สูงถึง 10-15 ล้านเหรียญดอลล่าร์ต่อปี และลดการปล่อยก๊าซคาร์บอนไดออกไซด์ไปได้ 801 ล้านตันต่อปี อย่างไรก็ดี แม้หลอดไฟ LED เข้าสู่ตลาดมาเป็นระยะเวลา 6-7 ปีแล้ว และราคาขายมีแนวโน้มลดลงอย่างต่อเนื่อง แต่อัตราการซื้อหลอดไฟ LED ของผู้บริโภคยังค่อนข้างน้อย เพียงร้อยละ 20 ของจำนวนหลอดไฟทั้งหมดที่ใช้ในประเทศไทย ดังนั้น การศึกษาเพื่อทำความเข้าใจทัศนคติและพฤติกรรมของผู้บริโภคในภาคครัวเรือนจึงมีความสำคัญอย่างมากเพื่อให้ภาครัฐและภาคส่วนที่เกี่ยวข้องกำหนดมาตรการจูงใจและส่งเสริมการปรับเปลี่ยนทัศนคติและค่านิยมของผู้บริโภคชาวไทยต่อการใช้หลอดไฟ LED ได้อย่างตรงจุดซึ่งจะช่วยให้ประเทศบรรลุเป้าหมายการพัฒนาที่ยั่งยืน (เป้าหมายที่ 7: สร้างหลักประกันให้ทุกคนสามารถเข้าถึงพลังงานสมัยใหม่ที่ยั่งยืนในราคาที่ย่อมเยา) วิทยานิพนธ์ฉบับนี้ประกอบด้วยการวิเคราะห์ในสามมิติ คือ การวิเคราะห์โดยใช้ทฤษฎีเชิงจิตวิทยา การวิเคราะห์โดยใช้ทฤษฎีเศรษฐศาสตร์พฤติกรรม และการวิเคราะห์การรับรู้ด้านราคา โดยในส่วนแรก การศึกษานี้มีวัตถุประสงค์เพื่อค้นหาปัจจัยที่มีผลต่อพฤติกรรมผู้บริโภคในการเลือกซื้อหลอดไฟแอลอีดี โดยใช้ทฤษฎีพฤติกรรมตามแผน (Theory of Planned Behavior) เป็นกรอบทฤษฎีหลัก ในส่วนที่สอง สืบเนื่องจากการทบทวนวรรณกรรมในสาขาเศรษฐศาสตร์พฤติกรรมแสดงให้เห็นว่า มีปัจจัยที่เรียกว่า “อคติเชิงพฤติกรรม” ที่มีอิทธิพลและขัดขวางผู้บริโภคในการตัดสินใจที่ดีที่สุดเพื่อเพิ่มอรรถประโยชน์ของพวกเขา ดังนั้น ในการศึกษาครั้งนี้ จึงมีวัตถุประสงค์เพื่อค้นหา “อคติเชิงพฤติกรรม” ที่เกี่ยวข้องกับบริบทของพฤติกรรมการซื้อผลิตภัณฑ์หลอดไฟแอลอีดี ในส่วนที่สาม เนื่องจากในปัจจุบัน หลอดไฟแอลอีดีมีราคาที่ลดลงอย่างมาก ส่งผลให้ปัจจัยด้านราคาไม่มีผลอย่างสำคัญต่อพฤติกรรมของผู้บริโภคเท่าเมื่อก่อน การศึกษานี้จึงต้องการวิเคราะห์การรับรู้ด้านราคาของหลอดแอลอีดีโดยใช้เครื่องมือที่เรียกว่า Price Sensitivity Measurement ศึกษาความอ่อนไหวต่อราคาของผู้บริโภค และกำหนดราคาที่เหมาะสมที่สุดของผลิตภัณฑ์นั้น จากการศึกษาสามารถแบ่งข้อค้นพบสำคัญสามประการ ประการแรก ผลการวิจัยชี้ให้เห็นว่าปัจจัยด้านทัศนคติมีผลกระทบโดยตรงอย่างมีนัยยะสำคัญสูงที่สุด ในขณะที่ปัจจัยด้านการคล้อยตามกลุ่มอ้างอิงส่งผลต่อความตั้งใจซื้อหลอดไฟแอลอีดีต่ำที่สุด นอกจากนี้ ยังพบว่าทัศนคติมีอิทธิพลโดยตรงอย่างมากต่อพฤติกรรมการซื้อหลอดไฟแอลอีดี ประการที่สอง การศึกษานี้ค้นพบ “อคติเชิงพฤติกรรม” ที่ส่งผลในการเลือกใช้หลอดไฟแอลอีดี คือ (1) ความพึงพอใจในปัจจุบันกับหลอดไฟ (ไม่มีประสิทธิภาพ) ที่ใช้อยู่ และ (2) นิสัยดั้งเดิมในการซื้อหลอดไฟชนิดเดียวกันที่เคยซื้อมาก่อนหน้านี้ ในด้านผลการวิจัยเรื่องความรู้เกี่ยวกับข้อมูลของหลอดแอลอีดีพบว่า กลุ่มตัวอย่างส่วนใหญ่นั้น เมื่อถูกถามเกี่ยวกับประโยชน์ของหลอดแอลอีดี ไม่ทราบว่า "หลอดไฟแอลอีดี มีระยะเวลาคืนทุนที่สั้นที่สุด" และ "หลอดไฟแอลอีดี เป็นมิตรกับสิ่งแวดล้อม" ประการสุดท้าย ผลการวิจัยพบว่า ความแตกต่างของการยอมรับด้านราคาของผู้บริโภคที่เคยใช้หลอดแอลอีดี เปรียบเทียบกับผู้บริโภคที่ไม่เคยใช้หลอดแอลอีดี สะท้อนถึงความเต็มใจที่จะจ่ายสำหรับอุปกรณ์ประหยัดพลังงานคุณภาพสูง เช่น หลอดแอลอีดี (willingness-to-pay a premium for LED bulb) กล่าวคือ ผู้บริโภคที่มีประสบการณ์การใช้งานหลอดแอลอีดี ให้มูลค่าสูงกว่าผู้ที่ไม่เคยใช้หลอดไฟแอลอีดี เนื่องจากการรับรู้ถึงประสิทธิภาพในการประหยัดพลังงานของหลอดแอลอีดี ผลการศึกษานี้นำไปสู่ข้อเสนอแนะเชิงนโยบายสำหรับผู้กำหนดนโยบาย ภาคเอกชนและนักการตลาด ในการพัฒนากลยุทธ์ด้านการเปลี่ยนแปลงพฤติกรรมผู้บริโภค การสื่อสารกับผู้บริโภคอย่างมีประสิทธิภาพ และกลยุทธ์การกำหนดราคา เพื่อส่งเสริมการบริโภคหลอดไฟประหยัดพลังงานแอลอีดีในประเทศไทย

สาขาวิชา	สิ่งแวดล้อม การพัฒนา และความยั่งยืน	ลายมือชื่อนิสิต .....
ปีการศึกษา	2562	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

5987835320 : MAJOR ENVIRONMENT, DEVELOPMENT AND SUSTAINABILITY
KEYWORD: environmentally sustainable behavior, Theory of Planned Behavior, consumer behavior, LED bulbs, behavioral economics, Thailand

Nuttakrij Apipuchayakul : PURCHASING BEHAVIOR OF LED LIGHTBULBS OF THAI CONSUMERS. Advisor: Dr. SUJITRA VASSANADUMRONGDEE

Electricity use in residential sectors has become one of major demands for global energy production and consumption.One of today's most energy-efficient lighting products is a Light-Emitting Diode (LED) lighting technology. The efficiency of LED lighting technology has already surpassed all other forms of lighting products such as traditional incandescent and Compact Fluorescent Lamp (CFL). Replacement with highly efficient lighting appliances like LED products could generate more than 10-15 billion USD of national energy-savings a year, or save up to 801 Mt of CO_2 emissions annually. Even though LED technology have been introduced in the lighting market since 2014 coupled with its substantial price drop; the total LED adoption rate in Thailand accounted for fewer than 20% of the 4-5 billion light bulbs in use. A study to understand attitudes and behaviors of household consumers is therefore very important for governments and relevant authorities to determine effective incentive measures and promote changes in Thai consumers' attitudes and norms towards the use of LED lighting. This underlines the necessity for Thailand to achieve the United Nations Sustainable Development (Goal 7: Ensure Access to Affordable, Reliable, Sustainable, and Modern Energy for All). This thesis analyzed three major dimensions; psychological theory dimension, behavioral economics dimension, and perception of price dimension. First, this study aims to examine the determinants of household consumers' behaviors in purchasing energy-saving lighting products LED (Light-Emitting Diode by applying the Theory of Planned Behavior (TPB) as the main theoretical framework. Secondly, research in psychology and behavioral economics show that there are certain "behavioral anomalies" influenced and impeded consumers in making optimal decisions to maximize their utilities. In this regard, this study aimed to empirically investigate the "behavioral anomalies" within the context of LED product purchase behavior, particularly through the lens of behavioral economics. Third, in order to catch up with recent substantial decline in LED products; this study aims to present the Price Sensitivity Measurement (PSM) to determine the optimal price of energy-efficient LED bulbs. There are three main key findings of this thesis. First, the results suggested that attitude has the largest direct effect, while subjective norm was the weakest predictor of purchase intention towards LED products. An important additional finding is that attitudes have a strong direct influence on the purchasing behavior for LED products. Second, major behavioral anomalies to adopting LED bulbs at home were their (1) current satisfaction with the previous (inefficient) light bulbs and (2) habits of buying the same light bulb types, i.e., those recently adopted at home. Majority of the samples don't know that "LED bulb has the shortest payback period" and "LED bulb is environmentally-friendly" when they were asked about the LED's benefits. Finally, the results confirm that the optimal price point is different across two different consumer groups. LED users value the product higher due to their previous direct experience of the product's efficiency, than those who have never experienced the product's efficiency in energy-saving. The discrepancy between optimal prices across two different groups accounts for the incorporated WTP for premium towards energy-efficient products.The study's findings highlight several implications for policymakers, private sectors, and green marketers in developing practical strategies, effective behavioral interventions, efficient communication messages, and pricing strategies to encourage the adoption of LED products in Thailand.

Field of Study:	Environment, Development and Sustainability	Student's Signature .....
Academic Year:	2019	Advisor's Signature .....

ACKNOWLEDGEMENTS

I would like to thank my advisor Dr. Sujitra Vassanadumrongdee for her support during my studies. She has been invaluable in guiding me throughout my study. Her insight, encouragement, and intellectual suggestion not only shaped this thesis, but tremendously improved my understanding of what it means to be a researcher. I am so grateful to have her as my advisor.

Chulalongkorn University benefits from a large group of interdisciplinary researchers interested in the field of environment, development, and sustainability issues. I would like to thank Associate Professor Dr. Dawan Wiwattanadate and Assistant Professor Dr. Suthirat Kittipongvises for many helpful comments and suggestions. They have given me tremendous support and encouragement throughout this long process. I also thank Assistant Professor Dr. Penradee Chanpiwat for helping me selecting journals for publication.

I also thank Assistant Professor Dr. Kanittha Tambunlertchai, who has always supported me throughout my study life. She was my advisor during my Bachelor Degree, wrote a letter of recommendation to apply for the University in the UK for my Master Degree, and gave valuable suggestions on my PhD thesis.

Associate Professor Dr. Peera Charoenporn has always encouraged me to pursue my ideas, which has been a great help through those inevitable times of doubt. Thank you so much.

Aleena Pathirapong, has been so helpful in helping me to administer survey and interview. This means a lot to me.

And most importantly, thanks to my parents, my brother and my sister who give me unconditional love and support for as long as I can remember.

Nuttakrij Apipuchayakul

TABLE OF CONTENTS

Page

LISTS OF TABLES

LISTS OF FIGURES

CHAPTER 1 INTRODUCTION

1.1. Background Information

1.1.1. Energy Efficiency Policies in Thailand

Over the past few decades there has been a substantial increase in electricity consumption, the strongest growth coming from the increased ownership and usage of electrical appliances in the residential sector (Antunes et al., 2012; Taylor et al., 2010). Several countries have integrated energy efficiency as a partial solution to energy-related challenges such as the increasing electricity consumption per capita, increasing population and rising fossil fuel costs, among others (Reynolds et al., 2012). Energy efficiency, as one of the key national policies to address environmental challenges, has become a priority in many countries, particularly in developing countries like Thailand, which has created the Energy-Efficiency Development Plan (EPPO, 2015).

An improvement in energy-efficiency is one of Thailand's key strategies to maintain energy security and at the same time reduce GHG emissions, according to the Energy Efficiency Development Plan 2015 (EPPO, 2015). According to the data from Electricity Generating Authority of Thailand or EGAT (EGAT, 2016) on an annual electricity report, electricity consumption at household level is almost one-third of total electricity consumption in the country, which increased by 10.11% from last year. Individuals and households are responsible for a certain share of the total energy consumption at a national level. Achieving a substantial reduction in energy consumption of these sectors would reduce reliance on energy imports and contribute to an improved environmental quality of a country. In other words, promoting energy conservation behaviors would play a vital role for the future of sustainability.

There has been a serious consideration on energy efficiency and several campaigns launched by the Thai government in order to promote energy-saving

behavior. The Ministry of Energy in collaboration with the Electricity Generating Authority of Thailand has launched the program called “Divided by Two” or "รวมพลังหาร 2 คิดก่อนใช้" since 1996 to encourage people to conserve energy by illustrating various benefits from changing their behaviors to efficient energy use and choices. To date, this campaign is the main public activity on energy-conservation policy implementation that welcomes supports from various sectors in the society.

Afterwards, the Energy-Efficiency Label #5 (ฉลากประหยัดไฟเบอร์ #5) was implemented by the Ministry of Energy in 2006 - aiming to help consumers make better decisions of energy-efficient choices by providing them with energy-saving potentials (where 5 = highest efficiency rating, 1 = lowest rating), yearly operating costs of various household appliances (e.g., ACs, fridges, TVs, fans, and light bulbs). Later in 2014, the Bureau of Energy conservation under EPPO had launched a new public campaign known as “Phalang Kid Sakid Loke” (พลังคิด สะกิดโลก). The campaigns aimed at encouraging energy conservation practices in educational institutions & younger generations through competition, and thus rewarding energy-saving champions among schools and colleges (Energy Policy and Planning Office, Ministry of Energy, 2014). The main target groups of these campaigns are always residential sectors, aiming at raising people’s awareness in efficient energy consumption and how their consumption patterns can be improved by simply changing energy-wasting habits or lifestyles.

1.1.2. LED Lighting: Background, Market and Policy

Global household energy consumption in lighting products accounts for 15% of global electricity consumption and 5% of greenhouse gas emissions worldwide (IEA, 2019). It is estimated that the improved efficiency of lighting appliances from traditional incandescent lamps to light-emitting diode (LED) lamps could save up to 801 Mt of CO_2 emissions annually, virtually equivalent to displacing more than 684 coal-fired power plants (Clean Energy Ministerial, 2018). Similarly, according to the United Nations Environment Program report in 2017 (UNEP, 2017), developing

countries could avoid almost $40 billion in electricity expenses and reduce CO_2 emissions by 320 million Mt annually by simply shifting to LED lighting technology.

Looking at the characteristics of LED products, they serve as a sustainability solution in several different ways. Firstly, LEDs consume less energy than other lighting product types, contributing to less demands for electricity generation. Secondly, LEDs last longer and are more durable than other types, thus minimizing waste generation from usage. Thirdly, they are made from recyclable materials and no harmful chemicals are used in construction (IEA, 2019).

When compared to Incandescent or Compact Fluorescent Light bulbs (CFLs), Light Emitting Diode (LEDs) typically last 25 times longer and consume at least 75% less energy than incandescent lighting, particularly those rated by ENERGY STAR. When it comes to making choice in bulbs between LEDs and CFLs, LED lighting products are of course much more efficient than CFLs in terms of average life-span, power consumption in KWh, but their purchase costs are relatively higher. One distinct advantage of LEDs bulbs over CFLs is that, it does not contain hazardous chemicals such as Mercury unlike the CFLs do, and it generates relatively three times less CO2 emissions/year than the CFLs (LEDs: 451 pounds/year, while CFLs: 1051 pounds/year).

There has been no future for incandescent light bulbs in many parts of the world; the 100-Watt incandescent light bulb was phased out in 2010 in the US, to be followed by 75-, 60-, and 40-Watt. Bloomberg Business reported that the replacement with more efficient lighting would be worth around 10-15 billion USD of national energy-savings a year. Additionally, the US Department of Energy reported that the adoption of LED lighting over standard incandescent in the next 20 years will prevent around 40 new power plants from being constructed, which could generate more than $265 billion in energy savings and will decrease estimated demand for electricity by 33% by 2027 (US Department of Energy, 2017).

Global Market of LED

The LED market is mainly driven by increasing demand of its long-lasting lifespan and its cost-effectiveness. Several governments across the world have established strong regulations on both production and consumption of LEDs sector in order to increase the deployment of such technologies in those countries. Countries like China, South Korea, and Japan have witnessed large demand growth of the LED lighting in their domestic market, according to the market research by Zion (2015). In Europe and North America, stringent environmental regulations in these countries have been the main driving force for increasing demands for LED lighting products - particularly by the growing concerns of CO2 emissions as well as uncontrollable growth of urbanization. The environmental benefits could shift people's mind to adopt this type of environmentally-friendly technologies within their households. However, the main challenges of LED lighting market have been remained in its high purchase price and low awareness among users in terms of its technical & environmental benefits (Zion, 2015).

Residential, outdoor and architectural lighting segments are three major applications of LED lighting technology. Above all of these segments, residential segments dominated the global LED market share; accounted for more than 40 per cent of the global market in 2014 – followed by architectural and outdoor segments. At global level, the market share of LED is mainly dominated by Europe – particularly France, Germany, and the UK. It is expected that the Asia-Pacific region will become major contributor in the strong growth of the LED lighting market resulting from rapid urbanization and stringent government regulations in the region. Countries like China, South Korea, India, Japan and particularly Thailand will be major growth markets for LED lighting in the years to come.

LED Market in Thailand

Thailand's Light-Emitting Diode (LED) lighting market has emerged as a fast-growing market holding great potential with a share approximately 12 per cent of total lighting market share, while the market value is expected to reach at $2.244 Billion (80

Billion THB). The domestic market is increasingly competitive in price by the penetration of several LED manufacturers, which in turns, become increasingly popular to Thai consumers across different sectors, according to Kasikornthai business analysis (2016). The table 1.1 below demonstrates the fast-growing market share of LED lighting products from 2013 – 2016;

Table 1.1. Thailand's Lighting Market and LED market share

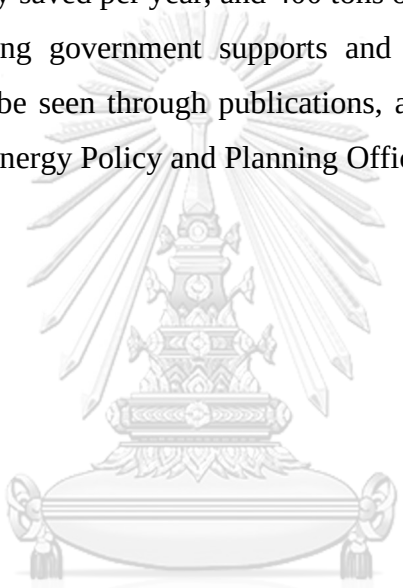
YEAR	Light bulb Market	LED lighting market
2013	7,470 Million THB	1,069 Million THB
2014	7,340 Million THB	1,532 Million THB
2015	6,670 Million THB	1,715 Million THB
2016	6,099 Million THB	2,043 Million THB

Source: Philips Electronics (Thailand), April 2016, Marketeer.

With the main goal to reduce total energy consumption by 20% by 2030, the Electricity Generating Authority of Thailand (EGAT) has initiated the Demand-Side Management programs (DSM) since 1993 – aiming to promote the use of energy-efficient equipment in various sectors. One of the DSM programs focuses on encouraging the use of efficient lighting appliances which ensure energy-savings eco-friendliness. One of the benefits from the DSM strategies to promote the use of LED lighting is that; at least household sectors have adopted more LED products as they realized large potential energy savings, coupled with constantly declining purchase prices of such technologies.

Since the demand for LED lighting continues to rise as the technology gains popularity worldwide, Thailand's Ministry of Energy has launched several campaigns to encourage the use of LED lighting products. In collaboration with the Electricity Generating Authority of Thailand (EGAT), the Ministry of Energy decides to host the LED Expo annually since 2012; with the overarching mission to welcome visitors from

various business spheres to explore the use of LED for numerous applications in both residential and commercial usage. In addition, there has been an increase in the use of LED products in government authorities as a means to reduce their energy consumption in the offices by 10% and periodically report the progress throughout the year since 2012. The energy-efficiency procurement in government includes 11 government offices totaled 299,000 LED lighting products. In 2014, EGAT targeted the adoption of LED products in several Royal Development project learning centers for more than 20,000 bulbs, which is equivalent to electricity saved by 800,000 units per year, equals to 3 million THB energy saved per year, and 400 tons of CO2 emissions are preserved per year. Clearly, strong government supports and commitments in LED-related campaigns, which can be seen through publications, annual reports, magazines, and television broadcasts (Energy Policy and Planning Office (EPPO); (EPPO, 2015).



1.2. Research Problem

More attention has been paid to large companies as well as government agencies across Thailand in sustainable energy conservation through adopting energy-efficient products such as LED lighting products in the buildings (EGAT, 2016) in order to address environmental issues more seriously. However, in Thailand, the adoption of energy-efficient products is still at an unsatisfactory level, particularly relating to the use of energy-efficient lighting products such as LEDs. The statistics show that LED products accounted for fewer than 20% of the 4–5 billion light bulbs in use in 2015 (EGAT 2016). With an attempt to address growing concerns over climate change and CO_2 emissions, the adoption of LED products—being the most advanced technology—by large consumers is necessary to significantly reduce society's heavy dependence on fossil fuel generation and greenhouse gas emissions. Particularly in developing countries like Thailand, the authors' own calculations project that, if the commercial and household sectors adopted LED lighting products for half of their current usage, Thailand as a whole would enjoy large energy-savings amounting to a cost of up to 40,949.9 million Thai baht per year, which is equivalent to 29.4% of total electricity consumption for lighting purposes (source: authors' own calculation). Clearly, an adoption of a more efficient product would benefit not only the end-consumers, but also the environment.

In an attempt to understand consumers' energy-efficient purchase behaviors, the majority of studies in the literature in this field has paid attention to covering the variation in product types (e.g., air-conditioners, televisions, washing machines, etc.) (Tan et al., 2017); (Ali et al. 2019); Hua & Wang, 2019). However, the results from these studies are unable to be generalized, since some factors may differ with various types of products. In fact, based on the currently available literature, we found only one previous study related to the adoption behavior related to LED lamps in Thailand (Leelakulthanit, 2014). The study, conducted in 2014, aimed at investigating factors affecting the intention to buy LED lamps among Bangkok consumers. So far, no research efforts have been made in the last five years to examine LED products in studying energy-efficient purchase behavior in Thailand. It is important to note that,

during the past few years, consumers have witnessed substantial technological advancement as well as an increase in price competitiveness in energy-efficient products, which has facilitated new behavioral patterns (IEA, 2019). There is a scarcity of literature on the specific types of energy-efficient products, particularly LED products, which have already surpassed the efficiency and quality of existing technologies such as Compact Fluorescent Lamps (CFL) and incandescent lights.

In recent years, energy-efficiency policy discussions have argued that individuals may be imperfectly informed about actual energy costs when they purchase energy-consuming products such as ACs, televisions, washing machines, and lightbulbs. Theoretically, the best policy to address imperfect information would be an information provision which is argued to be powerful and cost-effective. Provision of information through various several energy-saving campaigns have been implemented to fully informed about their energy costs, the product attributes, and encouraging pro-environmental behaviors. However, there is little evidence on how efficiently these information campaigns positively affect their purchase decisions, especially in the lightbulbs market in Thailand.

The current energy-efficiency policy debates have recognized that the failures of consumers to make energy-efficient investments despite its large potential savings as the "energy-efficiency gap". The term argued that the apparent reality that some energy-efficient products which would promote socially efficient outcomes are not adopted. The discussions of these studies suggest that the way consumers make decisions about investments in energy-efficient technologies could eventually lead to a slow diffusion of energy-saving products than would be expected. In lightbulb markets in Thailand, there is the discrepancy between the increased energy-efficiency level of LED products with numerous supports from government authorities and the adoption level actually realized.

Recently, certain numbers of psychological and behavioral studies have proposed that systematic behavioral anomalies and cognitive biases in consumer behavior can explain the energy-efficiency gap (Allcott, Mullaniatha & Taubinsky

2014; Tietenberg, 2009). Proponents of this viewpoint described systematic biases which differs from the standard economic assumptions. Consumers often act in ways that both fail to align with their current knowledge, attitudes, and intentions, and sometimes fall short of maximizing their personal benefits. Previous literatures argued that certain behavioral anomalies are contributing to the energy-efficiency gap and help to explain the gap (Gillingham et al, 2009; Shogren & Taylor 2008). As such, these deviations from traditional economic assumptions must be able to explain the inefficiently low adoption of LED products in Thailand.

In addition, this thesis also paid attention to the prices of LED products and how prices appeal to consumers influence their decision-making processes. During the last 5 years, the prices of an LED bulb have been substantially declined from approximately 1,100 THB to around 100 – 150 THB per bulb (EGAT, 2016). In this regard, prices of energy-efficient products like LED bulbs would not be considered as major determinants of their purchase decisions due to their increase in price competitiveness over normal bulbs. However, some economists argued that consumers as price-takers would accept prices at any given level by the producers. Marketers acknowledge the view that consumers often assess price information by decoding prices based on their knowledge from previous purchase experiences, informal communication messages (friends, families, etc.), or formal communication channels (advertising, online, information campaigns, etc.) (Kotler & Keller, 2005). These assessments of information lead buyer to form their perception of prices.

To a large extent, perception of price is more important than the actual price of the product. Consumers react to the prices differently, in which perception of prices could influence their decision-making processes, rather than the actual monetary price (Asamoah & Chovancova, 2011). For instance, when consumers have much more information on the perceived quality or value of the product, they might value the product more than those who did not have the same information. As such, when formulating pricing strategies, it is crucial to note that perception of prices plays an important role in buyers' purchase decisions. To the best of author's knowledge, there is clearly a lack of literatures focusing on examining consumers' perception of prices

of LED products. With the aim to increase the adoption of LED products in Thailand, it is important to investigate how consumers nowadays perceive prices of LED products, particularly to catch up with substantial decline in LED retail prices. Businesses as well as marketers that understand the role price perception plays in their pricing strategies can generate higher sales and revenues of energy-efficient products like LED bulbs.

1.3. Research Objectives

This thesis consisted of three main research objectives attempting to address current research problems and gaps found in the literatures. Each research objective will be fulfilled by three components in this study; (1) theoretical analysis in psychology, (2) behavioral analysis, and (3) price analysis.

Research Objective 1: The study seeks to empirically investigate purchase behavior related to energy efficiency in the context of LED lighting products. This study applies the Theory of Planned Behavior (TPB) as the main theoretical framework to investigate determinants and antecedents of purchase behavior.

Research Objective 2: The study aims to understand LED product purchase behavior from the perspective of behavioral economics. Specifically, this study attempts to investigate "behavioral anomalies" influencing the purchase behavior of LED products.

Research Objective 3: Regarding an increase in price competitiveness of LED products; the study aims to understand how consumers nowadays perceived the prices of LED products.

CHAPTER 2 LITERATURE REVIEW

2.1. Psychological Analysis of Understanding LED Purchase Behavior

This study required a theoretical model that could adequately capture significant aspects of human behavior; it needed to be simple, with a strong predictive ability and be applicable for certain adaptations in order to match the research objectives. After extensive research of the available theoretical options, this study decided to apply the model based on the Theory of Planned Behavior (TPB) developed by (Ajzen 1991) (Figure 2.1). The TPB argues that attitude, subjective norm, and perceived behavioral control combined together have positive causal relationships with intention, which leads to an execution of behavior. The model has been one of the most widely used frameworks for investigating environmental behaviors, and several researchers strongly agree that the TPB model can explain the behavioral intentions of sustainable consumption and predict future consumption behavior (Fielding et al., 2008; Mannetti et al., 2004; Ritter et al., 2015).

Literature on energy-efficient appliances has concentrated on investigating consumer intentions to purchase energy-saving home products. Although several behavioral researchers have improved the explanatory power of TPB by including some cognitive factors (Fielding et al., 2008; Mannetti et al., 2004; Ritter et al., 2015), there is a scarcity of literature giving empirical evidence on both purchase intention and purchase behavior towards energy-saving home products in this framework. Previous literature has focused more on investigating consumers' purchase intentions rather than actual purchase behaviors (Tan et al., 2017); (Ali et al. 2019); (Hua & Wang, 2019), while some previous studies have researched the inconsistency between intention and behavior towards sustainable products (Ritter et al. 2015). This creates an acute research gap in investigating the relationship between consumers' purchase intention and purchase behaviors towards energy-efficient products like LEDs. The TPB framework can not only help to examine factors affecting purchase behaviors towards

LED products, but will also offer certain empirical evidence of the relationship of all constructs which collectively represent consumers' actual purchase behaviors.

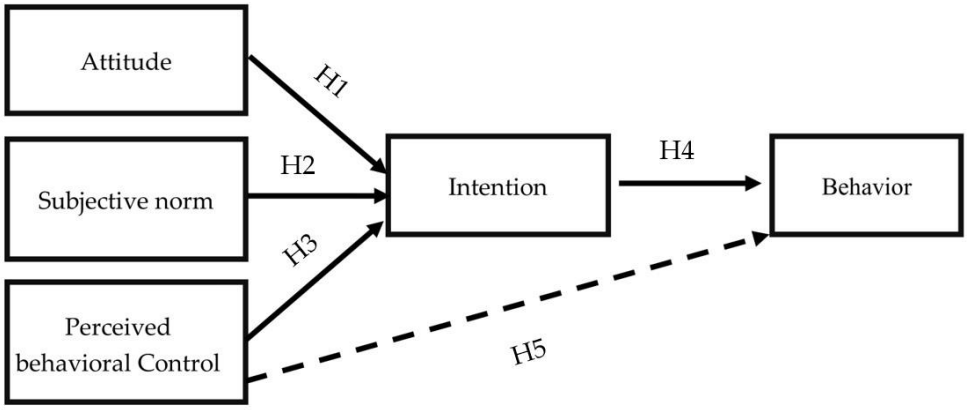


Figure 2. 1 Theory of Planned Behavior (Ajzen 1991).

Recently, the TPB model has become academically popular due to its ability to measure various constructs in different contexts and settings. This study uses the TPB model to examine the purchase behavior of LED products, which are discussed below.

2.1.1. Attitude and Purchase Intention

Attitude is a determinant of purchase intention, i.e., an interaction in memory between a given product and psychological evaluation of the product (Fazio, 1995), and somehow predicts actual human behavior (Ritter et al., 2015). Numerous studies have agreed on the strong relationship between attitude and behavioral intention. For instance, Mostafa (2007) found that attitude plays a major role in predicting intention in many cultures. Similarly, Birgelen et al. (2009) described that if consumers have strong positive attitude towards the environment, they are more likely to purchase environmentally-friendly products. In fact, a number of studies show that Thai consumers have positive attitudes towards green products (Patanadul 2015; Maichum et al., 2017; Saichao, 2016), which reflects positive influences on purchase intention towards green products. Based on the literature review, this study believes that attitude will have a positive influence towards purchasing energy-efficient products like LED products. As a result, the hypothesis (H1) can be drawn:

Hypothesis 1 (H1): *Attitude towards LED products is positively associated with purchase intention towards LED products.*

2.1.2. Subjective Norm and Purchase Intention

Subjective norm refers to consumers' perceived peer pressure, which dictates that they behave in certain ways in order to meet social expectations (Armitage & Conner, 2010); (Chang, 1998). Consumers are more likely to perform or not perform particular behaviors based on whether the behavior meets social expectations or not. Numerous studies have found a positive relationship between subjective norm and purchase intention in green purchase behavior (Ajzen I. , 2008) (Han, Hsu, & Sheu, 2011), environmentally conscious behavior (Moser 2015; Tsarenko 2013), and particularly green products consumption in Thailand (Wiriyapinit 2007). In support of this, recent studies have found that subjective norm is an important determinant of purchase intention of energy-saving products (Sutton, 2004); (Tanner, 2003). The empirical evidences from past studies have confirmed the role of subjective norm on the purchase intention of energy-efficient home appliances. As such, this study proposes that subjective norm has a positive effect on purchase intention towards purchasing LED products.

Hypothesis 2 (H2): *Subjective norm is positively associated with purchase intention towards LED products*.

2.1.3. Perceived Behavioral Control and Purchase Intention

Perceived behavioral control (PBC) refers to an individual's perceived difficulty or ease to perform a particular behavior. In other words, PBC consists of two aspects. One aspect refers to the consumer's confidence to perform a given behavior, whereas another aspect relates to the availability of resources (e.g., time and money) required for performing a behavior (Ajzen 1991; Taylor & Todd 1995). A number of studies reported a positive causal relationship between PBC and purchase intention in various contexts including green products (Moser, 2015), energy-saving intention (Sutton

2004) and environmentally conscious consumption behavior (Fielding et al., 2008; Collins & Carey 2007). Therefore, this research hypothesized the following:

Hypothesis 3 (H3): *Perceived behavioral control is positively associated with purchase intention towards LED products.*

2.1.4. Purchase Intention and Purchase Behavior

Purchase intention refers to the extent to which consumers think they will buy such products (Blackwell, 2001). It is obvious that consumers with a high intention to buy will be more likely to perform the purchase behavior than those who have no intention of buying (Brown, 2003). According to Ajzen (1991), purchase intention acts as a strong indication of an individual's readiness to perform a given behavior, which is argued to be an antecedent of behavior. Numerous studies confirmed a strong positive relationship between purchase intention and purchase behavior in different contexts (Thøgersen & Ölander 2003; Sheppard 1988). More importantly, this positive relationship has also been confirmed in empirical studies focusing on the purchase of energy-saving home products (Tan et al., 2017); (Ali et al. 2019); (Hua & Wang, 2019).

In addition, according to the TPB model, purchase intention will directly affect actual purchase behavior. However, in order to better predict actual purchase behavior, PBC, together with purchase intention, can be used to determine the actual behavior (Ajzen 1991; Chang 1998). In other words, PBC is also thought to have a direct influence on actual behavior; PBC is often used as a substitute for a measure of actual purchase behavior (Ajzen 1991). Within the context of purchasing LED products, this study expects that purchase intention and PBC will act as important determinants of purchase behavior. In this regard, the following hypotheses are proposed:

Hypothesis 4 (H4). *Purchase intention is positively associated with purchase behavior towards LED products*.

Hypothesis 5 (H5). *Perceived behavioral control is positively associated with purchase behavior towards LED products.*

2.1.5. Attitude and Purchase Behavior

Empirical studies have found that favorable attitudes towards environmental protection positively affect green purchase intention and behavior (Yadav & Pathak 2017; Chaudhary & Bisai 2018). Specifically, consumers who believe that pro-environmental behavior is crucial for environmental protection were more likely to adopt energy-efficient home appliances (Antunes et al., 2012; Taylor et al., 2010). Within the context of purchasing LED products, this study hypothesizes that attitude will have a strong direct influence towards purchase behavior. Therefore, the following hypothesis (H6) can be drawn:

Hypothesis 6 (H6). *Attitude is positively associated with purchase behavior towards LED products.*

In addition, purchase intention was hypothesized to act as a mediating variable between all the relationships of exogenous variables (attitude, subjective norm, and PBC) and purchase behavior. The additional hypotheses were proposed as follows;

H7: Purchase intention mediates the relationship between attitude and purchase behavior.

H8: Purchase intention mediates the relationship between subjective norm and purchase behavior.

H9: Purchase intention mediates the relationship between perceived behavioral control and purchase behavior.

2.1.6. Socio-Demographic Variables

Additionally, previous studies suggest that demographic variables play important roles in influencing pro-environmental purchasing behaviors (Moser, 2015); (Yadav & Pathak 2017); (Chaudhary & Bisai 2018). In support of this, socio-demographic characteristics such as education, age, gender, income level, and home ownership have been identified as key determinants of the sustainable consumption behavior of energy-efficient products (Han, Hsu, & Sheu, 2011); (Mostafa, 2007). Understanding

consumers' characteristics are necessary for targeted consumer segmentation and tailored marketing campaigns, particularly in developing countries like Thailand. Based on voluminous literature concerning demographic impacts on green purchase behaviors, this study attempts to investigate the effects of socio-demographic variables on the purchase behavior related to LED products. Therefore, this paper aims to investigate the following socio-demographic factors (including gender, age, education level, residence, monthly household income, home ownership, family member, and electric bill paying status) adapted from previous similar studies (Ritter et al. 2015; Mostafa 2007; Birgelen 2009).

2.2. Behavioral Analysis of Understanding LED Purchase Behavior

Based on traditional economic assumption models, consumers will make decisions which yield the optimal outcome given budget constraints, and such behavioral choices can be improved by providing people with more information, increasing personal knowledge, and/or more choices (Frederiks, Karen, & Hobman, 2015, pp. 1385–1394). The mainstream of green commodity and behavior predominantly suggest that consumers today are more environmentally-conscious than at the start of the millennium. Various societal actors (e.g., media, governments, NGOs, private sectors) have provided them with numerous rationales to "green" their lifestyles (Prothero & Fitchett, 2000); (Prothero, et al., 2011).

However, a growing body of research in psychology and behavioral economics show that consumers often act in ways that both fail to align with their knowledge, attitudes, intentions, and fall short of maximizing their personal benefits. Despite the shift in the dominant social paradigm regarding green consumption, consumers' environmental attitudes and values often fail to translate into actual purchases of green products such as energy-efficient appliances. This disconnection, if left unaddressed, will continue to hinder an effective transition to a low-carbon society. Whereas the gap shows that individuals are boundedly rational in the energy choices; energy-related practices are often influenced by certain "cognitive biases" and "behavioral anomalies"

which influencing decisions and behaviors that may be surprising from the standpoint of conventional economic theories.

Empirical evidence from behavioral economics and psychology shows that consumer choices and behaviors are often deviate systematically from neo-classical economic assumption of rationality, while there are certain "behavioral anomalies" in human decision-making which regularly alter behavior that these assumptions are unable to account for (Pollitt & Shaorshadze, 2013); (Kahneman & Tversky, 2000); (Kahneman, 2003); (Stern P. , 1992). Due to their limitations in cognitive processes, they have difficulties understanding the situation they are in and suffer from an imperfect ability to process new information (Ariely, 2008); (Thaler & Sunstein, 2008) and often fail to act upon their long-term intentions (Allcott & Taubinsky, 2015). For instance, people use mental shortcuts to deal with complexity, dislike losses more than they like gains, evaluate things in relative term rather than absolute term, and are heavily influenced by the people around them.

Therefore, this present study seeks to empirically investigate the "behavioral anomalies" within the context of LED (Light-Emitting Diode) lighting product purchase behavior, particularly through the lens of Behavioral Economics. By taking a case of LED products, this study argues that Thai consumers are deviated from making optimal decisions in energy choices (i.e. purchasing LED products) due to some certain "behavioral anomalies". By looking such anomalies through the lens of behavioral economics would enrich more understanding of consumer behavior towards purchasing energy-efficient products, and perhaps explain why adoption of LED products has been slower than expected in the country.

Consumer behavior is complex and rarely follows traditional economic theories of decision-making. When purchasing products, people often think they are making smart decisions and behaving in ways that are highly rational with their values and intentions. However, our daily life shows that this is not always the case. In fact, they routinely deviate from the "rational choice model" of consumer behavior, whereas individual objectively weighs up the benefits/costs of all alternatives before making

optimal decisions/actions. Neither is the decision-making reliably predicted by what individuals perceive as the “best” or “right thing to do”. For instance, individuals may hold environmental values or have positive attitudes towards sustainable products such as renewable energy sources - do not reliably translate into pro-environmental choices when buying products that impact the environment (Frederiks, Stenner, & Hobman, 2015).

It is clear that what individuals ‘say’ and ‘do’ are sometimes different. For example, people may intrinsically hold positive attitudes towards the environment; however, these things do not translate into actual behavior. One domain of consumer behavior where the discrepancy is evident is the purchase behavior of energy-efficient products (Flynn et al., 2010); (Huddart-Kennedy, Beckley, McFarlane, & Nadeau, 2009); (Abrahamse & and Steg, 2009); (Kollmuss & Agyeman, 2002). Yet even with adequate knowledge of how to save energy and a desire to do so, individuals still fail to take noticeable steps towards energy-efficiency and conservation. Hence, it is perhaps unsurprising that conventional education campaigns or programs which strive to promote pro-environmental attitudes through providing information - often fail to produce the durable behavior change that is intended (Abrahamse, Steg, & Charles, 2005); (Schultz, 2014).

As with much of human behavior, particularly energy-related practices are often influenced by certain “behavioral anomalies” which influencing decisions and behaviors that may be surprising from the standpoint of conventional economic theories. But they are rather ‘predictable’ from the perspective of psychology and behavioral economics (Shogren, 2012); (Pollitt & Shaorshadze, 2013). Nevertheless, these anomalies are often overlooked by policymakers and practitioners seeking to promote energy efficiency and conservation practices. This paper argues that it is important to take these behavioral anomalies into account when developing strategies for encouraging the uptakes of energy-efficient products like LED bulbs. By understanding these predictable deviations from rational economic behavior - insights from psychology and behavioral economics are highlighted to identify factors influencing the purchase behavior of LED products. A number of “behavioral

anomalies" factors that seems to particularly relevant to understanding the purchase behavior of LED products are outlined below;

This section provides an overview of the possible "behavioral anomalies" influencing the purchase behavior of LED products applied from the field of psychology and behavioral economics. The variables described in this research are expected to discourage the purchase of LED products. In other words, these factors act as barriers to purchasing LED products. Such anomalies are; Time-inconsistent Preferences, Habits, Endowment Effects (or Sunk Costs), Status Quo Bias, Availability Bias, and Satisfice. This section provides an overview of the possible influencing factors;

2.2.1. Time Inconsistent Preference

The time-inconsistent preference bias refers to a situation when people perceived things as less valuable or less significant if further away in time, even if such things afford long-term benefits (Thaler R. , 1981); (Gill, Atlas, & Hardisty, 2016); (Hardisty, Shim, Sun, & Griffin, 2017). For instance, people often 'discount the future' by preferring smaller immediate rewards (e.g., $5 now) over larger future rewards (e.g., $10 next year), while they may avoid actions which are costly in the short-term (e.g., outlaying money and time to purchase new energy-efficient appliances, or making an effort to switch energy retailers), despite offering larger long-term benefits (e.g. reductions in electricity expenses). This tendency to be 'short-sighted' and make 'time-inconsistent judgements' is expected to act as major barrier in purchasing LED products.

Since the investment costs of energy-efficient measures are generally large (e.g., greener product choices, less pollutions, etc.), while the tangible benefits are often delayed and gradually accrued over time, policymakers should pay more attention to energy-saving payoffs in the longer terms in consumer-focused messages. For instance, a study by Hershfiled et al. (2011) suggested that connecting consumers with their "future selves" lead to larger contributions to savings and future rewards. In particular,

when designing consumer-focused strategies, it is important to note that consumers should be more immediately rewarded for doing positive actions ‘now’ which will lead to greater future benefits (like energy-saving actions at home).

2.2.2. Endowment Effects (Sunk-Costs Effects)

The sunk-cost bias occurs when money or efforts have already been invested in a particular endeavor, people tend to become irrationally fixated on ‘recovering’ losses already suffered, discounting future benefits/costs (Garland, 1990; Thaler, 1980). Once such efforts, time, and money has been invested, they may persist with that course of action and ‘throw good many after bad’ even as it becomes riskier or increasingly unlikely to yield the desired outcomes.

The effects of sunk-cost bias have been observed for both businesses and individual decision-making across a wide range of experimental contexts (Garland, 1990). Particularly in the residential energy domain, for example, A consumer who outlays time, money and effort to purchase an electrical appliance may tend to use it more, even when it is not necessarily required. More importantly, they may continue the usage of inefficient appliances until its lifetime has finished, rather than replacing with more efficient equipment and enjoying energy-saving benefits.

In this regard, policymakers should frame messages in order to reduce the salience of large costs they already outlaid for energy-inefficient appliances they failed to upgrade, replace, or discard (e.g., inefficient and outdated Incandescent light bulbs). In the same manner, policymakers should emphasize on any ongoing costs associated with retaining inefficient appliances – such as presenting higher electricity bills, larger carbon emissions, or increased energy consumption from outdated appliances. Research shows that providing information on better alternatives for achieving returns on investment may increase the likelihood that abandonment of inefficient products seems like a more positive action (Northcraft & ANeale, 1986). By focusing on offering consumers incentives or rewards for investing in energy-efficient products such as

upgrading appliances – would be effective. As such, measures which focusing on the potential benefits from taking energy-saving actions (i.e., replacing old inefficient lighting products) rather than losses/costs which have already been incurred.

2.2.3. Satisfice

The satisfice bias refers to the extent to which people exert only the effort needed to achieve a satisfactory (‘good enough’) rather than an optimal (‘best’) result (Simon, 1955); (Brown, 2004). In other words, when overloaded with information complexity, people tend to choose not necessarily the best option to a problem, but rather the available option that “suffices”, or satisfies the minimum requirements (Kahneman, 2003). However, the tendency to choose ‘good enough’ option may come at a cost; i.e., people often making worse decisions and poorer choices when faced with several choices of energy-efficient appliances. In fact, they may tend to choose options which satisfied their needs, rather than the most efficient appliances available to them.

There are certain simplification strategies which can help facilitate more efficient decision-making or reduce cognitive overload in aspect of energy conservation. Policymakers should draw attention to designing a desired action simpler, quicker, and easier to perform the actions (e.g., default settings, automatic technology, or generating risk-free environment) (Schultz, 2014); (Verplanken & Wood, 2006). In other words, keeping instructions simple and short is vital for effective communication. One should avoid presenting consumers with too many energy-saving choices, instead framing messages only the most important information. A number of field studies have found that giving more choices is not desirable, and may fail to produce long-term behavioral change (Iyengar & Lepper, 2000).

2.2.4. Status Quo Bias

The People tend to retain the status quo, stick to default settings, or even defer decision-making entirely, particularly when the complexity or amount of information rises (Samuelson & Zeckhauser, 1988). For instance, consumers may resist change and

‘go with the flow’ or pre-set options, even where alternatives may yield better personal (more financially rewarding, materially advantageous) or collective outcomes (positive outcomes to greater public). In context of energy-efficient purchase decisions, people may tend to resist change and prefer keeping the status quo investment option, even where alternatives may yield better personal (e.g., more energy-saving potentials) or collective outcomes (CO2 emissions reductions from increasing efficiency at home). As such, the purchase behaviors of LED products or other more-efficient products could be interrupted when decision-makers overly weigh previous decisions to inform current decisions (Samuelson & Zeckhauser, 1988).

Effective behavioral interventions for addressing status quo bias can be enhanced by directly targeting energy-efficient measures which are effortlessly adapted or easily modified, particularly by using the default settings. For instance, recent technology of washing machines has their default setting to “eco-mode” program (McCalley, 2006). Alternatively, behavioral interventions which encourage consumers to shift from the status quo such as offering ‘free trial’ or ‘try before you purchase’ campaigns would trigger their decisions, so that people are more amenable to change (Verplanken & Wood, 2006); (Schultz, 2014).

2.2.5. Availability Bias

The availability bias occurs when people draw on readily available information that is easily accessible in memory and springs to mind quickly from their personal anecdotes such as recent experiences (Tversky, Amos, & Kahneman, 1974); (Gabrielcik & Fazio, 1984). Particularly, people tend to estimate the frequency of future events by drawing heavily on the information most readily available in memory, which inevitably produces biased estimates of the likelihood of different outcomes that are relevant to their decision-making (Taylor, 1982); (Tversky, Amos, & Kahneman, 1974). In respect to purchasing behavior, people may estimate their future purchase decisions based on the information most readily available in memory/experience, which in turns, may inevitably produces biased estimates of the outcomes which are relevant

to their purchase decisions. For instance, people who have experienced only inefficient appliances would tend to estimate the future purchase decisions by drawing heavily on the information/experience in inefficient appliances. Therefore, the behavioral failure may arise when such biased estimates of the different outcomes inevitably influence their decision-making.

To address availability bias, consumer-focused messages should provide examples of energy-efficient measures which are readily available in their cognitive memories. Using various media channels to bring energy conservation to the forefront of their consciousness and make it a social norm or common practice. A study by Schultz (2014) found that simple prompts and reminders can effectively increase pro-environmental behaviors, particularly those who are already motivated to engage in a desired action. Thaler & Sunstein's example of an "Ambient Orb" - a light bulb that signal the degree of energy consumption at home (it glows red when the energy usage is high, but turns green when it is low) can effectively reduce peak energy usage by almost 40% (Thaler & Sunstein, 2008).

2.2.6. Habits

Habits refer to behavioral routines in purchasing products that are repeated on a regular basis and tend to happen subconsciously (Ajzen I. , 2008). Among the personal factors, habits were found to be the most significant variables in the review studies of attitude-behavior inconsistency (Kollmuss & Agyeman, 2002); (Aarts, 2000); (Ramayah, Lee, & Mohamad, 2010).

As regards to habits and green purchasing behavior, (Kollmuss & Agyeman, 2002) believe that habits strongly and negatively influence green purchasing behavior. Consumers are not persistent enough in practicing new behavior until it becomes a habit. When out of habit green products are never purchased - it is very hard for a consumer to change this habit into purchasing green products (Aarts, 2000).

Most of the consumers choose the products they have always bought, instead of putting in extra effort to change behavior and be socially responsible. In other words, if a person has strong habits related to buying non-eco-friendly products; there is a high probability that s/he will not consider to start buying such products, even if s/he understands that they are better/ healthier/ safer, etc. Hence, it can be argued that consumers' habits may act as important barriers in purchasing energy-efficient products like LED bulbs.

The formation of good habits may be motivated by intrinsic (non-pecuniary) rewards such as recognition, praise, and social approval should be emphasized on to incentivize energy-saving actions. Research suggested that such intrinsic rewards may have stronger consistent behavioral impacts than monetary incentives (Seaver & Patterson, 1976), and durable behavioral change over the longer term (Stern & Gardner, 1981); (Schultz, 2014).

Table 2.1. Summary of Behavioral Anomalies and Policy Implications

Construct /Definition	Context of Energy-efficient purchase	Policy Implications
Time Inconsistent Preferences	People tend to perceive things as less valuable or significant if further away in time, even if such things afford long-term benefits. In fact, discounting the future explains why adopting energy-efficient products are difficult to implement (Gamma, Reeck, & Weber, 2015); (Hardisty, Appelt, & Weber, 2009); (Tangari & Smith, 2012). They may avoid actions that are costly in short-term (e.g., outlaying time and money to purchase new energy-efficient appliances), despite offering longer-term benefits (e.g., reduced electricity bills)	Policymakers should pay more attention to energy-saving payoffs in the longer terms in consumer-focused messages. For instance, a study by Hershfiled et al. (2011) suggested that connecting consumers with their "future selves" lead to larger contributions to savings and future rewards. In particular, when designing consumer-focused strategies, it is important to note that consumers should be more immediately rewarded for doing positive actions 'now' which will lead to greater future benefits (like energy-saving actions at home).
Endowment Effects (or Sunk-Costs Effects)	People tend to become irrational fixated on 'recovering' losses already invested, discounting future costs/benefits (Garland, 1990; Thaler, 1980) A consumer who outlays time, money and effort to purchase an electrical appliance may tend to use it more, even when it is not necessarily required.	Policymakers should frame messages in order to reduce the salience of large costs they already outlaid for energy-inefficient appliances they failed to upgrade, replace, or discard (e.g., inefficient and outdated Incandescent light bulbs). In the same manner, policymakers should emphasize on any ongoing costs associated with retaining inefficient appliances – such as presenting higher electricity bills, larger carbon emissions, or increased energy consumption from outdated appliances. By focusing on offering consumers incentives or rewards for investing in energy-efficient products such as upgrading appliances – would be effective. As such, measures which focusing on the potential benefits from taking energy-saving actions (i.e., replacing old

		inefficient lighting products) rather than losses/costs which have already been incurred.
Satisfice	In other words, when overloaded with information complexity, people tend to choose not necessarily the best option to a problem, but rather the available option that "suffices", or satisfies the minimum requirements (Kahneman, 2003); (Simon, 1955); (Brown, 2004). People often making worse decisions and poorer choices when faced with several choices of energy-efficient appliances. In fact, they may tend to choose options which satisfied their needs, rather than the most efficient appliances available to them.	Policymakers should draw attention to designing a desired action simpler, quicker, and easier to perform the actions (e.g., default settings, automatic technology, or generating risk-free environment) (Schultz, 2014); (Verplanken & Wood, 2006). In other words, keeping instructions simple and short is vital for effective communication. One should avoid presenting consumers with too many energy-saving choices, instead framing messages only the most important information. A number of field studies have found that giving more choices is not desirable, and may fail to produce long-term behavioral change (Iyengar & Lepper, 2000).
Status Quo Bias	When overwhelmed or lacking time, decision-maker overly weighs previous decisions to inform current decision (Samuelson & Zackhauser, 1988) People tend to resist change and prefer keeping the status quo investment option, even where alternatives may yield better personal/collective outcomes (e.g., more energy-saving potentials)	Effective behavioral interventions for addressing status quo bias can be enhanced by directly targeting energy-efficient measures which are effortlessly adapted or easily modified, particularly by using the default settings. For instance, recent technology of washing machines has their default setting to "eco-mode" program (McCalley, 2006) . Alternatively, behavioral interventions which encourage consumers to shift from the status quo such as offering 'free trial' or 'try before you purchase' campaigns would trigger their decisions, so that people are more amenable to change (Verplanken & Wood, 2006); (Schultz, 2014).
Availability Bias	People tend to estimate the frequency of future events by drawing heavily on the information most readily	Consumer-focused messages should provide examples of energy-efficient measures which are readily available in their cognitive memories. Using various

	available in memory, which inevitably produces biased estimates of the likelihood of different outcomes that are relevant to (Kahneman & Tversky, 2000); (Gabrielcik & Fazio, 1984)	media channels to bring energy conservation to the forefront of their consciousness and make it a social norm or common practice. A study by Schultz (2014) found that simple prompts and reminders can effectively increase pro-environmental behaviors, particularly those who are already motivated to engage in a desired action. Thaler & Sunstein's example of an "Ambient Orb" - a light bulb that signal the degree of energy consumption at home (Thaler & Sunstein, 2008).
Habits	Habits strongly and negatively influence green purchasing behaviour (Kollmuss & Agyeman, 2002). When out of habit green products are never purchased - it is very hard for a consumer to change this habit into purchasing green products (Aarts, 2000)	The formation of good habits may be motivated by intrinsic (non-pecuniary) rewards such as recognition, praise, and social approval should be emphasized on to incentivize energy-saving actions. Research suggested that such intrinsic rewards may have stronger consistent behavioral impacts than monetary incentives (Seaver & Patterson, 1976), and durable behavioral change over the longer term (Stern & Gardner, 1981); (Schultz, 2014).

2.3. Price Analysis of LED Products

Price is one of the important effects on consumer behaviors and their purchase decisions. Price signals the product quality. Oftentimes, when products were priced too low, consumers may raise suspicion about its features. If products were priced too high, consumers would end up never purchasing the products. As mentioned earlier that the price of an LED bulb has been dramatically dropped since 2015, from approximately 1,100 THB to around 100-150 THB per bulb. To the best of author's knowledge, current literatures have not paid attention to investigate consumers' perceptions towards prices of LED products which has substantially declined during the past few years. Therefore, a valid estimation of consumers' willingness to pay for the products are vital for designing optimal pricing strategies. However, prices of products like LEDs are varied based on total Watts and brands. Therefore, setting optimal prices of such products would be more suitable to identify price points within a range. One of the tools to identify optimal price range of the products is called the "Price-Sensitivity Measurement". This methodology is useful for providing an estimation of the acceptable price range which potential buyers would be willing to pay through indicating their lower and upper price thresholds.

Price Sensitivity Measurement (PSM) developed by the Dutch Economist Van Westerndorp (Van Westerndorp, 1976) is used to investigate how consumer perceptions of value are affected by the interaction of price and product quality. The PSM was first studied by (Gabor & Granger, 1966) who asked retail customers about upper and lower price limits in their minds when considering a product purchase. A number of empirical evidences show that the PSM analysis was applied in different sectors and manifested accuracy in indicating optimal price points. Carola et al. (2009) engage the PSM to estimate the pricing strategy in hospitality sectors and restaurant businesses. Kupiec & Revell (2001) applied PSM to estimate consumers' perceptions to the price of dairy products, while results revealed low price sensitivity.

The fundamental premise of PSM incorporates two common goals: 1.) To determine the threshold range in price and; 2.) To determine the stress price levels.

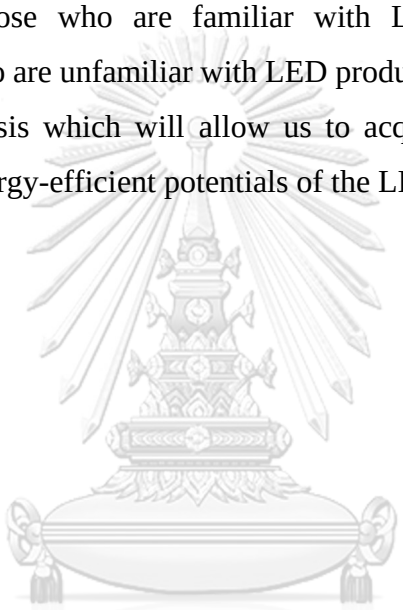
Furthermore, the model offers an estimation of the proportion of buyers who would purchase the products at any given price level. This methodology is utilized in various occasions such as estimating product development decisions determined on their willingness-to-pay for the product attributes (Kucher, Hełdak, Kucher, & Raszka, 2019), or predicting market demand for newly launched products (Biswas & Roy, 2016). The strength of this model lies on its relative simplicity and its inexpensive implementation in evaluating consumer's perception of values, which would further translate to pricing policies or marketing strategies.

To understand the role price acts in consumer's purchase choice decisions, it is important to measure the sensitivity of price perception of buyers. At price points lower than the threshold; demand drops rapidly due to their suspicions about the product's quality and its feature. On the contrary, at prices above the threshold; demand also drops since consumers would perceive the prices to be unaffordable in relative to the perceived benefits they acquired (Canavari, Nocella, & Scarpa, 2003). As such, the aim of measuring consumers' price threshold is to estimate the acceptable price range for a product.

When pricing a product, a producer often makes an error of pooling together buyers which are familiar with the product, with other buyers that are unfamiliar with the product. To encourage consumers that are unfamiliar with the product to adopt the product, it is important to know how much each consumer group values the product. Previous studies argued that the differences of consumers' values could be identified as the willingness-to-pay a premium for a product if they are familiar with the product (Chen & Hitt, 2001; Oh, 2000). In general sense, consumers who have previous direct experience towards the product are more likely to value the product than those who have never adopted such product. In case of purchasing LEDs, current LED consumers might witness an energy-efficiency potentials of LED products, making their perception of values seemingly higher than those who have never adopted LEDs at home. Previous literature attempted to differentiate the price perception of two consumers which are familiar and non-familiar with the product using PSM analysis in retail brand awareness. However, there is no evidence of the

usage of PSM in estimating the price perception of green products among different groups of consumers.

Therefore, the main aim of this study is to present a new approach of PSM analysis which allows to examine the optimal price points depending on the familiarity with the product. In this study, the author hypothesized that LED users would value the product higher than non-LED users due to their previous experience of the products. Specifically, this study attempts to explore the price perception of LED consumers (those who are familiar with LED products) and non-LED consumers (those who are unfamiliar with LED products) by applying an adjustment on using PSM analysis which will allow us to acquire their perceived values in accordance to the energy-efficient potentials of the LED products.



CHAPTER 3 RESEARCH METHODOLOGY

The main methodology in this research is a quantitative survey of Thai consumers in purchasing lighting products. The data collection method of this study is based on primary data which is collected in the form of self-complétion questionnaires via an online survey and a pre-test (face-to-face interview at an electrical shop in Bangkok).

Based on the proposed theoretical analysis, the constructs of attitude, subjective norm, perceived behavioral control, purchase intention and purchase behavior, derived from the Theory of Planned Behavior, will be analyzed for their causal inter-relationships using Structural Equation Modeling (SEM) through a program called "Analysis of Moment Structure" (AMOS 22). Attitude, subjective norm, and PBC were included as independent variables (Xs), while purchase intention and purchase behavior were the dependent variables (Ys); at the same time, purchase intention was included as a mediating variable of the three exogenous variables in terms of their effects on purchase behavior.

The sample for developing behavioral analysis and price analysis was collected at the same time as the theoretical analysis, the data were separated by a purchase decision scenario question in the main online survey questionnaire. The purchase decision scenario question about light bulb choice was included to separate them into two groups. The first group consisted of those who normally bought an LED bulb – they were considered as consumers who were familiar with LED products, or LED users. The second group are those who normally bought a traditional incandescent or a Compact Fluorescent Lamp (CFL) – classified as non-LED users who were not familiar with the LED products. Each of consumer groups were guided to different sets of questionnaires in the survey. The table below illustrated the question related to lightbulb purchase scenario.

Question: Normally, which types of light bulb you buy?

หลอดไส้	**หลอดตะเกียบ**	**หลอดแอลอีดี**
		
[01] ราคา: **25 บาท** Watt: **60W**	**[02]** ราคา: **74 บาท** Watt: **14W**	**[03]** ราคา: **148 บาท** Watt: **8W**

หลอดไส้ (Incandescent)_____01

หลอดตะเกียบ (CFL)_____ 02

หลอดแอลอีดี (LED)_____03

3.1. Scope of Study

Designing a sample starts with defining population of study. The main aim of this research is to understand the purchase behavior of LED products among Thai household consumers from three different aspects, i.e., theoretical, behavioral and price aspects. The author expected that respondents would include those who have experienced with the uses of LED products and those who have never used such products before. The rationale for collecting both targeted respondents is to fully understand the actual behaviors on both sides of consumers, particularly factors either affecting or hindering them to performing such behavior, and how they perceived prices of products.

According to this, the population of this study was defined as all individuals who are making decisions about purchasing lighting products and who have at least some basic knowledge about what energy-efficient lighting products are. The geographical focus of this present study will be based in Thailand.

3.2. Sampling Method

Findings which do not generalize to other samples are of little scientific significance. As such, the issue of generalizability which relates to the minimum requirement of participant samples is vital for data analysis. Nevertheless, numerous guidelines proposed by different authors incorporating numbers of required samples do exist. The sample for this research was customers who are living in Thailand and are over 18 years old with experience of purchasing lighting products.

Regarding the theoretical analysis, the required sample size acceptable for Structural Equation Modelling (SEM) using AMOS basically depends on model complexity as well as some other factors (e.g., multivariate normality, missing data, etc.) However, several researchers such as (Kline, 2011, pp: 11-12, Wolf et al., 2013) recommend having minimum sample sizes of at least 200, or 15 cases per parameters. In fact, it is always true that larger sample size generally produces more reliable outcomes. However, the decisions for minimum sample sizes should take into considerations a number of factors.

The following suggestions by (Hair et al., 2014, pp. 574) for the discussion of minimum sample sizes were presented below - based on the model complexity and its general characteristics:

- Sample Size (Minimum 100): suits for a model containing 5 or fewer constructs, each construct with more than 3 observed variable items, and with high item communalities (0.6 or higher)
- Sample Size (Minimum 150): suits for a model containing 7 or fewer constructs with moderate item communalities (0.5), and with no under-identified constructs.

- Sample Size (Minimum 300): suits for a model containing 7 or fewer constructs with lower item communalities (0.45 or less), and/or with multiple under-identified (<3) constructs.
- Sample Size (Minimum 500): suits for a model containing large numbers of constructs, having some items with lower communalities (0.45 or less), and/or with fewer than three measured items.

Based on this sampling method, the minimum sample size of 150 participants would suit this study's hypothesized model, and is adequate for conducting data analysis. Additionally, according to (Connelly, 2008), extant literature suggests that a pilot study sample should be 10-20% of the sample size anticipated for the parent study.

The survey questionnaire was first trialed with 30 light bulb customers at an electrical shop in Bangkok to gain a preliminary understanding of the survey content by conducting face-to-face interviews. After that, the questionnaire was revised for its clarity and suitability based on the customers' feedback. Then, the main study was conducted through online survey channels from January 2019 to August 2019 throughout Thailand by using a convenient sampling method for greater reach. In addition, qualitative results from face-to-face interviews are further investigated and discussed, particularly the behavioral barriers to adopting LED products at home.

3.3. Measures of Constructs

3.3.1. Constructs of Theoretical Analysis

The statements or constructs in the questionnaire were adapted from various studies in the literature which applied the TPB as the main instrument, in which a pre-test is required to ensure reliability and validity. All scale items were scored on a 5-point Likert-type scale ranging from (5) Strongly Agree to (1) Strongly Disagree. These

constructs were modified to suit this study and a summary of each variable is depicted in Table 3.1.

Table 3. 1 Example statements for influencing factors.

Constructs/Observed Variables	Source (s)
Attitude	
ATT1 (I believe that using LED bulb helps solve global warming issues and environmental degradation) ATT2 (I believe that using energy-efficient products is favorable) ATT3 (Helping relieve global warming by using energy-efficient products means an intrinsic reward for myself)	(Ritter et al. 2015; Mostafa 2007; Birgelen 2009)
Subjective Norm	
SN1 (Advice from others influenced my decision to adopt LED products) SN2 (People which influence my decisions think that I should use more EE products) SN3 (Nowadays, LED products are far superior to others)	(Ajzen 1991; Wiriyapinit 2007)
Perceived Behavioral Control	
PBC1 (I am confident that I can afford to buy an LED bulb in the future) PBC2 (I bought an LED bulb because it is easily available in my area) PBC3 (Decisions to buy LED and other energy-efficient products help society and the environment)	(Ajzen 1991; Taylor and Todd 1995; Sutton 2004)
Purchase Intention	(Ajzen 1991; Thøgersen and Ölander 2003; Sheppard 1988)
PI1 (In the future, I will definitely buy LED bulbs) PI2 (I intend to use LEDs in order to save energy at home) PI3 (If possible, I will share my knowledge about LEDs to others)	
Purchase Behavior	
PB1 (I bought an LED because I have used it previously; past behavior) PB2 (I always recommend others to adopt LED bulbs) PB3 (I normally buy an LED bulb, even if it is more expensive)	(Ajzen 1991; Chang 1998)

3.3.2. Constructs of Behavioral Analysis

The statements or constructs in the questionnaire are adapted from various studies of previous literature. It captures only those who are aware of their behavioral biases in purchasing LED products. These constructs are modified to suit this present study and are individually listed below. Summary of each variable is depicted in Table 3.2.

Table 3. 2 Example Statements of Behavioral Anomalies related to purchasing LED light bulbs

Behavioral Anomalies	Measurement Items	Source(s)
Time Inconsistent Preference	• I am more responsive to the upfront costs of LED products, rather than its energy-saving potentials	Adapted from (Hardisty, Appelt, & Weber, 2009); (Joshi & Fast, 2013)
Availability Bias	• My purchase decisions of lighting products are mainly based on convenience / availability of the products because I don't have time / efforts to concern about this issue	(Vermeir & Verbeke, 2006); (Borgstede & Biel, 2002); (Young et al., 2010)
Endowment Effects (Sunk-Costs)	• I still have many spare bulbs at home / wait until the old ones finished	Garland (1990)
Status Quo Bias	• I have used only CFL/Incandescents at home since my house was built / I have moved	Pichert & Katsikopoulos (2008);
Habits	• I automatically buy the same lighting products	(Bamberg, 2002); (Verplanken & Wood, 2006)
Satisfice	• I think my current light bulbs are already energy-efficient (satisfy with its efficiency)	Brown (2004);

3.4. Data Collection Method

The data collection method of this study is based on primary data which is collected in the form of self-completion questionnaires and a pre-test (using two instruments combined – face-to-face interview and pilot survey). The survey questionnaire was first trialed with 30 light bulb customers at an electrical shop in Bangkok to gain a preliminary understanding of the survey content by conducting face-to-face interviews. After that, the questionnaire was revised for its clarity and suitability based on the customers' feedback. Then, the main study was conducted through online survey channels from January 2019 to August 2019 throughout Thailand by using a convenient sampling method for greater reach. This section elaborates the uses of these two methods in this study.

3.4.1. Survey Data Collection

A self-completion questionnaire through an online channel is used as the main tool to collect data in this study. The main advantage of this quantitative instrument is the great reach, resulting not only in broad overview and general valid statements, but also offering the opportunity to calculate statistical coherence. A questionnaire will provide insights in order to accurately understand the purchase behaviors of Thai household consumers on LED products. Another advantage of the questionnaire is the anonymity for the respondents. Anonymity reduces the effects from the social desirability bias, even when respondents have to answer questions related to sensitive issues (Hardin & Hilbe, 2001).

There are a number of rationales supporting the use of self-completion questionnaires. Firstly, answers provided by participants will be comparable due to the equality of questions asked. Secondly, the elimination of the risk of an in-person bias is met since there is no direct contact between researcher and participants. And lastly, the benefit in favor of self-completion survey belongs to its simple and less time-consuming than other methods, which may result in an increasing number of survey answers. However, there are some concerns which needed to be addressed in this type

of instrument - the difficulties in understanding questions while participants receiving no assistance during the survey completion. More importantly, the major concern lies in the external validity and its generalizability of an online survey.

The issues of validity are of great significance to the findings of this research served as guarantees of the results of the respondents' performances and their actual behaviors. In this regard, validity refers to the degree to which a study reflects the specific concepts it aims to investigate, i.e., it aims to answer these two questions; Are the differences found related to the measurement? And can the findings be generalized? Thus, conducting interview observation as a supplement to quantitative surveys would allow researchers investigate participants' external behavior and internal beliefs – particularly ensure the internal validity issues of generalizability in this research. Therefore, this present study argues that using more than one data collection instrument would help obtaining richer data and validating research findings.

Hereby, a pre-test using two research instruments (face-to-face interview and pilot survey) are necessary in order to receive feedbacks from respondents prior to the actual surveys. Irrelevant questions will be either modified or eliminated.

3.4.2. Preliminary Interview (Pre-Test)

Two research instruments (face-to-face interview and pilot survey) are combined to optimize the structure of the main study (questionnaire survey). Researcher have paid more attention to face-to-face interview method during the pre-test studies to accurately understand respondents' purchase behavior of lighting products when the interviews were carried out during the purchase transactions of such products. Researcher expects qualitative findings from this study can be further discussed in order to understand what are the barriers to purchasing LED products.

3.5. Data Analysis

3.5.1. Structural Equation Modeling (SEM) Analysis

Regarding theoretical analysis, the Theory of Planned Behavior (TPB) was applied to understand the purchase behavior of Thai household consumers towards LED products by using the Structural Equation Modelling (SEM). The SEM, being the main data analysis tool, is conducted through the program called "Analysis of Moment Structure" (AMOS) 22 in order to test the causal relationships between hypothesized variables, Path Analysis and Structural Model.

A statistical program called "Statistical Package for Social Sciences (SPSS) is used as a main instrument in preparation for further data analysis in SEM. The SEM path analysis was developed to explain how well the hypothesized TPB framework predicts purchase behavior of Thai household consumers towards LED products - by estimating the significance and magnitude of the relationships between observed variables in the model (Kline, 2011) where;

- DV: Purchase Behavior towards LED products
- IV: Attitude, Subjective Norms, and Perceived Behavioral Control
- Mediating Variable: Purchase Intention

Prior to the data analysis, this study data was screened for missing data and outliers naming Univariate and Multivariate outliers in accordance with the recommendations by Kline (2011). The frequency distribution of z-scores of an absolute value greater than |3| were classified as univariate outliers, which were excluded from the data (Kline, 2011). Similarly, any data which have the values of Mahalanobis Distance (D2) more than the $\chi 2$ were considered as Multivariate outliers. These mentioned outliers will be deleted before computing the causal relationships of the model.

Prior to the standardized effects and results of the TPB model to be discussed in this present study, it is important that all required goodness-of-fit indices should be taken into account in the model. Kline (2011) suggested applying numerous goodness-

of-fit indices, including Chi-Square (Cmin/df), Comparative Fit Index (CFI), Goodness of Fit Index (GFI), Root Mean Square Residual (RMR), and Root Mean Square Error of Approximation (RMSEA) where;

- **Chi-Square (**Cmin/df) represents a "badness of fit" of a model which tests the discrepancy of the data - where the higher and statistically significant Chi-Square values indicates more data discrepancy (Kline, 2011). However, a number of literature (e.g., Wheaton, 1977; Byrne, 1989) have replaced the criteria for testing data discrepancy with a "**Relative Chi-Square**" (Cmin/df) as a measure of model fit. Ratios between 2 to 5 indicated a reasonable fit (Wheaton, 1977).
- **CFI** (Comparative-Fit-Index) expresses the relative improvement in model fit of the proposed model in comparison with a statistical baseline model fit (Kline, 2011, p. 196). The CFI has acceptable values of greater than or equal to 0.9 - representing a good fit in the criteria.
- **GFI** (Absolute-Fit-Index) indicates the variance (in %) in the co-variance matrix which was described by the model (Kline, 2011). Similarly, the GFI has acceptable values of greater than or equal to 0.9 - representing a good fit in the criteria.
- **RMR** (Root Mean Square Residual) is generally based on co-variance residuals - the smaller the values indicating better model fit (Kline, 2011). The recommend values of RMR should be close to zero but if RMR is <0.09, the data still considered as acceptable fit.
- **RMSEA** (Root Mean Square Error of Approximation) indicates a model fit parsimony-adjusted index - meaning that RMSEA is a continuous measure of model fit which corrects for model complexity (Kline, 2011). The ideal RMSEA is 0 indicating the best model fit; however, values greater than 0.08 means a poor model fit.

In addition, all these goodness-of-fit indices can be improved by re-specifying the model considering the relationships between variables as suggested by the Modification Indices (MI) output from the AMOS program. However, it should also be

noted that the model modification of SEM should be theory driven and must be made in step (Joreskog et al., 1993).

3.5.2. Statistical Analysis

- Descriptive analysis is applied for creating personal profile and general statistics of respondents.
- Cronbach's Alpha Coefficient - to calculate reliability of the hypothesized variables (Nunnally, 1978).
- A one-way Analysis of Variance (ANOVA) was conducted in to investigate the effects of socio-demographic variables on the purchase behavior related to LED products.
- Correlation Analysis is used to calculate the strengths and characteristics of the linear relationship between variables. It was used with Pearson Correlation Coefficient (r). The possible values can vary between -1 and +1 (Pallant, 2013). Cohen (1988) suggests next guidelines for determining of correlation strength:
  - r = 0.10 to 0.29 – correlation is small;
  - r = 0.30 to 0.49 – correlation is medium;
  - r = 0.50 to 1.0 – correlation is large.
- And one more important indicator is statistical significance (Sig. = .000). It shows if independent variable makes "statistically significant unique" prediction of dependent variable (Pallant, 2013: 167).

3.5.3. Price Sensitivity Measurement (PSM) Analysis

Regarding price analysis, the acceptable price range of an LED bulb will be investigated through the PSM analysis. The aim of the PSM is to use four questionnaires to determine the acceptable price points, particularly to identify an Optimum Price Point (OPP) of LED light bulbs in Thailand's context. This study determines the threshold price range of the LED bulbs by differentiated into two categories, i.e., consumers that are familiar with the LED bulb (LED users) and consumers who are unfamiliar (non-LED users). In this study, the author hypothesized that LED users would value the product higher than non-LED users due to their previous experience of the products. The price point that this study was used for comparison of their values is the Optimal Price Point (OPP).

To obtain the results of optimal price points, this study has already included four standardized PSM questions to form the analysis in the main online survey questionnaires. There are two groups of respondents, i.e., LED users and non-LED users. Each group will be asked about the four standardized PSM questions in order to examine the differences in perception of prices of each consumer groups. The price data were obtained by asking them the following questions;

Considering purchasing an LED bulb, please answer these four questions;

- At what price would you begin to think an LED bulb is too expensive to consider?
- At what price would you begin to think an LED bulb is so expensive that you would question the quality and not consider it?
- At what price would you begin to think an LED bulb is getting expensive, but you still might consider it?
- At what price would you think an LED bulb is a bargain – a great buy for the money?

Responses to these four questions were price points whose frequencies are plotted and accumulated for data analysis. According to Van Westerndorp (1976),

there are four curves, “cheap”, “not cheap”, “expensive” and not expensive” (see Figure 3.1.). This method aims to derive four critical points from the intersections of the price curves;

1. Indifference Price Point (IPP). The IPP is considered as the “normal” price at which the numbers of respondents who consider the product to be “cheap” is equal to the number of respondents for whom the product is “expensive”;
2. Point of Marginal Cheapness (PMC). The price point at which the same proportions of respondents consider the product as “not cheap” and “too cheap”;
3. Point of Marginal Expensiveness (PME). The price point at which the same proportions of respondents experience the product as “not expensive” and “too expensive”;
4. Optimal Price Point (OPP). The proportions of respondents considering the product as “too expensive” and “too cheap” are the same.

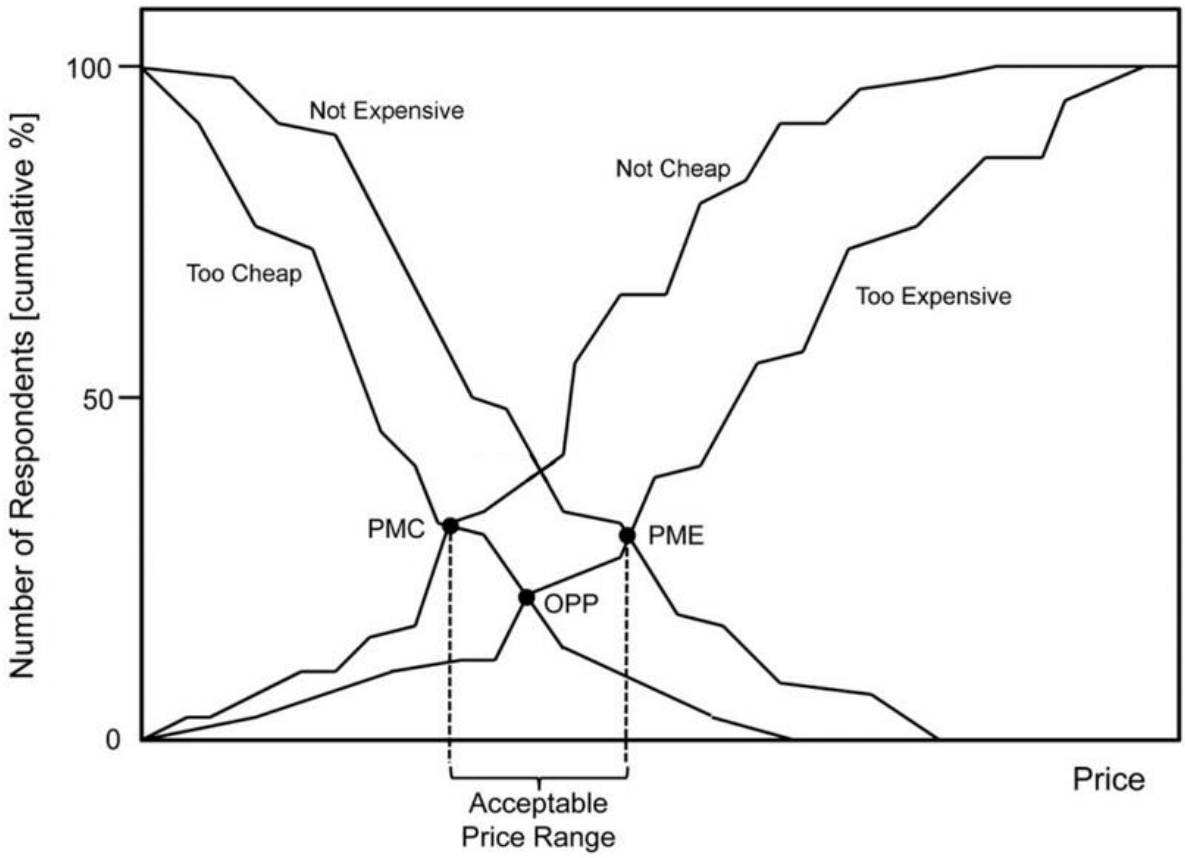


Figure 3. 1 The Van Westerndorp Price-Sensitivity Meter (Van Westerndorp, 1976)

3.6. Validity, Reliability & Ethical Considerations

Considerations about the quality and evaluation of research data include validity and reliability. In other words, interpretation of results is useful if data are valid and reliable. The validity of this study is particularly important, especially in quantitative research (Bryman & Bell, 2015).

Validity

This present study tries to ensure validity of data through the analyses of previous research and existing literature on the issues of energy-efficiency behavior and energy-efficient product adoption. The measurement validity in this study is strong since the measurement constructs for data evaluation can reflect the true conceptual terms. In fact, the measurement of constructs was carried out at 95% significant level. This confirmed significant causal relationship between hypothesized variables; therefore, the internal validity can be confirmed. However, we believed that the external validity of this study is weak as we analyze data from respondents on convenient sampling basis. Thus, it cannot cover the major part of our population.

Reliability

Reliability of the study refers to the reproducibility of the results, which means that the sources of the data are reliable and stable (Pierce, 2008). In this regard, the reliability of methods acts as a criterion to ensure the accuracy of measurements which indicates the robustness of the results obtained. The reliability of quantitative analysis through survey questionnaires will be measured at the first step of data analysis. The aim is to assess the properties of our measurement model. Items used for measuring each of the constructs are needed to ensure internal reliability (Bryman & Bell, 2015) through a general statistical test for measuring internal reliability – Cronbach's Alpha. Cronbach's alpha coefficient is widely considered as appropriate for assessing

reliability of scales of a survey. Any scales which indicated high internal consistency scores of above 0.7 was considered as acceptable values.

Ethical Considerations

Ethical issues are crucial in this research; to ensure that no one is harmed or suffers from negative consequences from this research study. In particular to the context of this study, the main issues lie in the confidentiality of data and anonymity of participants. In both quantitative survey and face-to-face interview, it is unproblematic guaranteeing anonymity of participants. In addition, regarding the requirements of informed consent, participants will be informed about the key points of this study at the beginning of the survey and interview – this to ensure that the data will solely be utilized within the context of the scope of study. Therefore, it is concluded that this research is in line with required ethical principles.

CHAPTER 4 RESULTS AND DISCUSSIONS

4.1. Factors Affecting Purchase Behavior of LED Products

4.1.1. Descriptive Statistics of TPB Constructs

The descriptive statistics of respondents are reported in Table 4.1. A total of 328 respondents were received, then the data were screened for missing data and outliers, leaving a final data set for analysis of n = 288. The majority of respondents were female (52%), are aged between 18 and 35 years (50%), have a Bachelor's degree (57%), live in Bangkok (83%), have a monthly household income in the range 25,000–75,000 THB (47%) ($1 = 30.23 THB as of 1 December 2019), own a house (86%), have a family size of 4–6 persons (45%), and are responsible for paying electric bills regularly (60%).

Table 4. 1 Descriptive statistics of survey participants (n = 288).

Category	Frequency	(%)
Gender		
Male	139	48%
Female	149	52%
Age		
Gen Y (18–35 years)	145	50%
Gen X (36–49 years)	104	36%
Baby Boomers (50–70 years)	39	14%
Education Level		
Lower than Bachelor's	35	12.4%
Bachelor's	165	57.3%
Higher than Bachelor's	87	30.2%
Other	1	0.1%
Residence		
Bangkok	240	83%
Other	48	17%

Household Income		
Low Income (0–25,000)	44	15%
Middle Income (25,000–75,000)	135	47%
High Income (75,000–100,000+)	109	38%
Home Ownership		
Owned	249	86%
Rent	39	14%
Family Member		
Small HH (1–3)	125	43%
Medium HH (4–6)	130	45%
Large HH (7–10+)	33	12%
Electric Bill Paying Status		
Unreported	2	0.7%
Never Paid	97	34%
Paid Some Months	15	5.3%
Paid Regularly	174	60%

HH, household. Source: Author's own calculation.

All items also indicated a significantly positive correlation in the inter-correlation matrix (the correlation is significant at the 0.001 level; two-tailed). As such, this suggested the appropriateness of the inclusion of all measure scales in the composite variables. According to Table 4.2, the results show that all three components of the TPB (attitude, subjective norm, perceived behavioral control) are significantly correlated with purchase intention - whereas the strongest relationships was with perceived behavioral control (r = 0.59), followed by attitude (r = 0.58) and subjective norm (r = 0.41) at significant level (p = 0.01). In addition, all inter-correlations were considerably lower than 1 - indicating that a discriminant validity was achieved (Ajzen, 1991).

Table 4. 2 Correlation Matrix of TPB Constructs

Correlations (Composite Variable)						
		Attitude	Subjective Norm	PBC	Purchase Intention	Purchase Behavior
Attitude	Pearson Correlation	1	.293**	.452**	.583**	.514**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	288	288	288	288	288
Subjective Norm	Pearson Correlation	.293**	1	.371**	.415**	.361**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	288	288	288	288	288
PBC	Pearson Correlation	.452**	.371**	1	.590**	.560**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	288	288	288	288	288
Purchase Intention	Pearson Correlation	.583**	.415**	.590**	1	.664**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	288	288	288	288	288
Purchase Behavior	Pearson Correlation	.514**	.361**	.560**	.664**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	288	288	288	288	288

**. Correlation is significant at the 0.01 level (2-tailed). (All sig at 2 stars)

The descriptive statistics of all composite variables in the hypothesized model were computed, as were the overall means for the variables of each construct. The mean scores indicated positive results for all parameters. Specifically, the mean scores show that survey participants had positive intention ($\bar{x}$ = 4.62); attitude ($\bar{x}$ = 4.61); perceived behavioral control ($\bar{x}$ = 4.55); purchase behavior ($\bar{x}$ = 4.31); and subjective norm ($\bar{x}$ = 4.14) in relation to energy-efficient products (Table 4.3.). It is appropriate in this study to use mean scores of all construct variables for data analysis since these variables were collected and derived using similar methods that facilitate the comparison across variables (as suggested by Ajzen, 2002; Francis et al, 2004). In addition, all scales indicated high internal consistency scores of above 0.7 (Cronbach's alpha: 0.789) (Table 4.4.). The Cronbach's alpha value indicates internal consistency between the three items that were combined to form the composite variable.

Table 4. 3 Descriptive statistics of the Theory of Planned Behavior (TPB) constructs (*n* = 288).

		Min	**Max**	**Mean**		**S.D.**	**Variance**
	Stat.	Stat.	Stat.	Stat.	S.E.	Stat.	Stat.
Attitude	288	3.33	5.00	4.614	0.025	0.427	0.183
Subjective Norm	288	2.00	5.00	4.140	0.043	0.739	0.547
Perceived Behavioral Control	288	3.33	5.00	4.556	0.024	0.420	0.177
Purchase Intention	288	3.33	5.00	4.627	0.026	0.446	0.200
Purchase Behavior	288	2.33	5.00	4.314	0.038	0.659	0.436
Valid n (listwise)	288						

Table 4. 4 Cronbach's Alpha Values

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.789	.822	5

Prior to the path analysis, the data were screened for missing values and univariate and multivariate outliers in accordance with the recommendations (Kline 2011). The survey data had very low rates of missing data since most of the survey questions required an answer to proceed in the survey. Missing data related to socio-

demographics questions were fulfilled by the mean scores of each component (e.g. mean scores of age, family member, etc.). Some of the survey data were deleted due to (1) Z-scores being greater than ±3 (univariate outliers), and (2) Mahalanobis Distance (D2) values being more than the χ^2 (multivariate outliers); leaving a final dataset of n = 288 for computing the relationships between each composite variable during the path analysis.

4.1.2. Testing the Structural Equation Modeling Analysis

This study employs Structural Equation Modelling (SEM) by analyzing through the Program called AMOS. The SEM path analysis was developed to explain how well the hypothesized TPB framework predicts purchase behavior of Thai household consumers towards LED products - by estimating the significance and magnitude of the relationships between observed variables in the model (Kline, 2011). There are three main steps in the Path Analysis: 1.) Model Specification, 2.) Model Estimation, and 3.) Re-specification of the Model.

Model Specification. During this stage, hypotheses were represented in a form of structural path diagram - derived from a strong theoretical rationale with causal relationships (Kline, 2011). Figure 4.1. illustrated the proposed causal relationships examining the purchase behaviors of LED products of Thai household consumers. The model is considered as recursive as it did not contain any feedback loops (Ajzen, 1991). On the other hand, for the model to be considered as identified - the degree of freedom (df) must be at least zero, where all latent variables should be scaled. According to the nature of a recursive model - this model automatically meets the general criteria for being considered identified (Kline, 2011).

Model Estimation. The Maximum Likelihood Estimation (MLE) from the statistical program called AMOS 22 was conducted to analyze structural path. The original hypothesized TPB model was examined to measure the causal relationships of variables through unstandardized as well as standardized effects. However, only the

standardized effects will be discussed in this present study. According to the AMOS output, all the direct effects in the hypothesized model were statistically significant. However, a number of general model-fit indices should also be taken into account in the model. It has been recommended (Kline 2011) to apply numerous goodness-of-fit indices including Chi-Square (Cmin/df), CFI, GFI, RMR, and RMSEA.

The CFI and GFI are two additional indexes of model fit which range from 1 (Best Fit) to 0 (Extremely Poor Fit). The CFI (Comparative-Fit-Index) expresses the relative improvement in model fit of the proposed model in comparison with a statistical baseline model fit (Kline, 2011, p. 196). Similarly, the GFI (Absolute-Fit-Index) indicates the variance (in %) in the co-variance matrix which was described by the model (Kline, 2011). Both CFI and GFI have acceptable values of greater than or equal to 0.9 (Table 4.5). The CFI (0.984) and GFI (0.986) were both greater than 0.90 in the original model - representing a good fit in these criteria.

The RMR (Root Mean Square Residual) is generally based on co-variance residuals - the smaller the values indicating better model fit (Kline, 2011). The recommend values of RMR should be close to zero but if RMR is <0.09, the data still considered as acceptable fit. In the original model, the RMR was (0.010), indicating a good fit for the data.

RMSEA (Root Mean Square Error of Approximation) indicates a model fit parsimony-adjusted index - meaning that RMSEA is a continuous measure of model fit which corrects for model complexity (Kline, 2011). The ideal RMSEA is 0 indicating the best model fit; however, values greater than 0.08 means a poor model fit. RMSEA for the original model was (0.120) thus indicating a poor fit. Table 6 shows the criteria for general Goodness-of-Fit indexes in comparison to the original model. Overall, from the proposed model, the results indicated inappropriate fit for both the Chi-Square/df (Cmin/df = 5.128; not fit) and RMSEA values (RMSEA = 0.120; not fit).

Table 4. 5 Goodness of Fit Indices (Original Model)

Model Fit Indices	Recommended Value	Model Value (Original Model)
Chi-Square/df (Cmin/df)	<3 good; <5 sometimes permissible	5.128 (Not Fit)
p-value for the model	>0.05	0.06
CFI	≥ 0.9	0.984
GFI	>0.95	0.986
AGFI	>0.80	0.896
RMR	<0.09	0.010
RMSEA	≤ 0.08; (<0.05 good)	0.120 (Not Fit)
TLI	≥ 0.9	0.918
NFI	≥ 0.9	0.980

Model Re-Specification. Model fit indices can be improved by re-specifying the model considering the relationships between variables as suggested by the Modification Indices (MI) output. The MI results suggest that the model could be improved by adding a few structural paths. However, it should be noted that structural equation modelling should be theory driven, modification should made with theoretical grounding. As Joreskog et al. (1993) states that a structural path (suggested by the MI output) with the largest MI values should be considered and modification must be made in step.

Table 4. 6 Modification Indices (from AMOS Output)

			M.I.	Par Change
Purchase behavior	<---	Attitude	5.438	.153

According to the AMOS output, the largest MI values (**5.438**) was described by the structural path from attitude to purchase behavior (Table 4.6). The suggested path indicates that household consumers' attitudes had a direct effect on their purchase behavior. Fazio (Fazio 1995) also found a statistically significant correlation between attitudes and purchase behavior. As such, the first modified structural model was developed by adding a structural path from attitude to purchase behavior.

The results of the first modified structural model were shown in Figure 4.1. The results of re-specifying model show that all goodness-of-fit indices were within

acceptable values. In particular, the Chi-Square/df (Cmin/df) were reduced to (Cmin/df = 1.660), and RMSEA values were reduced to (RMSEA = 0.048); other indices (i.e., RMR, GFI, AGFI) were within the acceptable range (Table 4.7). As such, the re-specified model was considered to be the final model since the MI did not suggest a need to add more meaningful paths.

Table 4. 7 Goodness-of-fit indices for the final model.

Model Fit Indices	**Recommended Value**	**Model Value (Final Model)**
Chi-Square/df (Cmin/df)	<3 good; <5 sometimes permissible	1.660
p-value for the model	>0.05	0.198
CFI	≥0.9	0.999
GFI	>0.95	0.998
AGFI	>0.80	0.965
RMR	<0.09	0.06
RMSEA	≤0.08; (<0.5 good)	0.048
TLI	≥0.9	0.987
NFI	≥0.9	0.997

CFI, Comparative Fit Index; GFI, Goodness of Fit Index; AGFI, Adjusted Goodness of Fit Index; RMR, Root Mean Square Residual; RMSEA, Root Mean Square Error of Approximation; TLI, Tucker Lewis Index; NFI, Normed Fit Index. Source: Author's own calculation.

4.1.3. Hypotheses Testing

Table 4.8 indicates the results of the structural model as well as their standardized path coefficients, which show positive direct effects among the TPB constructs. In total, all six hypotheses were supported.

Attitude has strong to moderate positive effect on purchase intention

H1 argues that attitude towards LED products is positively associated with purchase intention towards LED products. H1 was supported by the SEM output with a standardized path coefficient ($\beta = 0.37$, $p < 0.001$), indicating a moderate to strong positive relationship between attitude and purchase intention. More importantly, attitude was found to have the strongest weight among other direct predictors of purchase intention.

Subjective norm has moderate positive effect on purchase intention

H2 states that subjective norm towards LED products is positively associated with purchase intention towards LED products. H2 was also supported. It is also important to note that subjective norm had the weakest positive effect on purchase intention among the three main predictors, with a standardized path coefficient to purchase intention of $\beta = 0.17$, $p < 0.001$. This result is in accordance with one of the previous findings of a TPB study by Armitage & Conner (2010), which found that attitude has the largest direct effect on purchase intention and subjective norm is the weakest predictor of purchase intention.

Perceived behavioral control has strong to moderate positive effect on purchase intention

H3 suggested that PBC is positively associated with purchase intention towards LED products. H3 was supported as well, with a standardized path coefficient to

purchase intention of $\beta = 0.36$, $p < 0.001$. The result show that there is a moderate to strong positive relationship between PBC construct and purchase intention.

Purchase intention has strong positive effect on purchase behavior

H4 suggested that purchase intention is positively associated with purchase behavior towards LED products. H4 was supported, with a standardized coefficient to purchase behavior of $\beta = 0.44$, $p < 0.001$. The results indicate that there is a strong positive relationship between purchase intention and purchase behavior.

Perceived behavioral control has strong to moderate positive effect on purchase behavior

H5 argued that PBC is positively associated with purchase behavior towards LED products. H5 was supported, with a standardized path coefficient to purchase behavior of $\beta = 0.232$, $p < 0.001$. This means that there is a moderate positive relationship between PBC and purchase behavior.

Attitude has strong to moderate positive effect on purchase behavior

Lastly, H6 suggested that attitude is positively associated with purchase behavior towards LED products. H6 was supported, and the results indicated a standardized path coefficient from attitude to purchase behavior of $\beta = 0.154$, $p < 0.003$. This result shows that household consumers' attitudes had a direct effect on their purchase behavior (Figure 4.1.).

Table 4. 8 Standardized results of the final model.

			Estimate	S.E.	C.R.	*p*	Label	Hypothesis Results
Purchase Intention	<--	Attitude	0.370	0.050	7.811	***	par_1	H1 (Supported)
Purchase Intention	<--	Subjective Norm	0.174	0.027	3.824	***	par_2	H2 (Supported)
Purchase Intention	<--	Perceived Behavioral Control	0.358	0.052	7.349	***	par_3	H3 (Supported)
Purchase Behavior	<--	Purchase Intention	0.438	0.085	7.602	***	par_4	H4 (Supported)
Purchase Behavior	<--	Perceived Behavioral Control	0.232	0.082	4.424	***	par_5	H5 (Supported)
Purchase Behavior	<--	Attitude	0.154	0.080	2.954	0.003	par_9	H6 (Supported)

Note: *** *p*-value < 0.001.

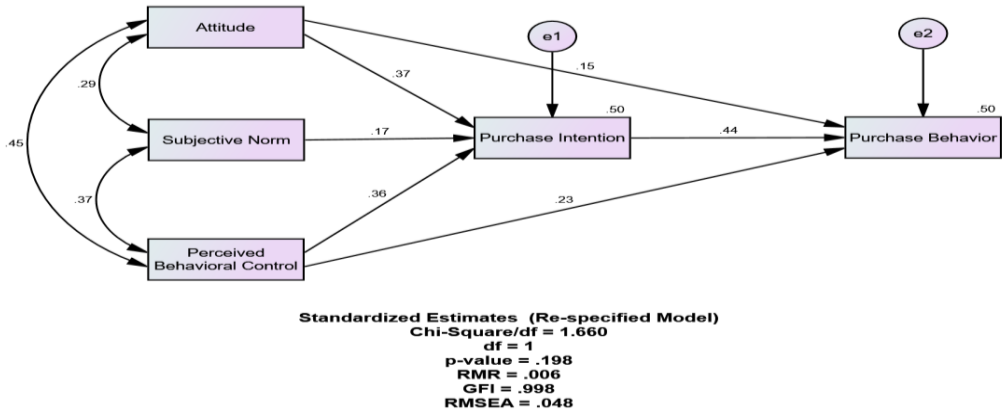


Figure 4. 1 Path diagram for the final model of theory of planned behavior to understand light-emitting diode (LED) product purchase behavior among Thai households.

Moreover, according to the Final Model, the SEM output also indicates the total and indirect effects. Table 4.9 and Table 4.10 below report the indirect effects estimation in order to test the mediating effects of Purchase Intention on the three relationships as hypothesized in H7, H8, and H9. The results show that the indirect effect estimates for all these hypotheses were insignificant and small, indicating that there are no mediating effects of purchase intention on these three relationships. In other words, the direct effects from the three independent variables (attitude, subjective norm, and PBC) towards purchase behavior were significantly higher when compared to indirect effects. As such, H7, H8, and H9 were rejected.

Table 4. 9 Indirect Effects of Variables Interaction

Exogenous	**Mediated**	**Endogenous**	**Path**	**Indirect Effect Estimate**	**Mediating Hypothesis**
Attitude	Purchase intention	Purchase behavior	ATT -> INT ->BEHAV (0.370 x 0.438)	0.162	Not Mediating
Subjective norm	Purchase intention	Purchase behavior	SN -> INT ->BEHAV (0.174 x 0.438)	0.076	Not Mediating
PBC	Purchase intention	Purchase behavior	PBC -> INT ->BEHAV (0.358 x 0.438)	0.157	Not Mediating

Table 4. 10 Total Effects of Mediating Variable

Exogenous	**Mediated**	**Endogenous**	**Path**	**Total Effect**
Attitude	Purchase intention	Purchase behavior	ATT -> INT ->BEHAV (0.154 +0.162)	0.316
Subjective norm	Purchase intention	Purchase behavior	SN -> INT ->BEHAV (0.000 +0.076)	0.076

Perceived behavioral control	Purchase intention	Purchase behavior	PBC -> INT ->BEHAV (0.232 +0.157)	0.389

Furthermore, the results indicate that these three exogenous variables (i.e., attitude, subjective norm, and perceived behavioral control) collectively explained 49.9% of the variance in purchase intention (Table 4.11). Similarly, purchase intention, attitude, and perceived behavioral control jointly explained 50.0% variance in purchase behavior towards LED products.

Table 4. 11 Squared Multiple Correlation Results

Endogenous Variable	**Square Multiple Correlation (SMC = R^2)**
Purchase intention	.499
Purchase behavior	.500

Additionally, an ANOVA test was conducted to investigate the effects of socio-demographic variables on consumers' purchase behavior towards LED products. However, only age factor and electricity bill paying status were found to have significant differences. Respondents were categorized into three age groups: Group 1 (Gen Y: 18–35 years old); Group 2 (Gen X: 36–49 years old); and Group 3 (Baby Boomers: 50–70 years old). The results discovered a statistically significance difference in purchase behavior scores between the three age groups, $F(2, 286) = 5.308$, $p = 0.05$. Post-hoc comparisons using the Scheffe test revealed the mean score for Group 3 (M = 4.55, SD = 0.53) was significantly higher than the mean score for Group 1 (M = 4.20, SD = 0.71) (Table 4.12).

Table 4. 12 Age groups – ANOVA and Post-hoc comparisons using Scheffe test

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Purchase Intention MEAN	18 - 35 Yrs	144	4.567	.489	.040	4.486	4.647
	36 - 49 Yrs	104	4.692	.398	.0391	4.614	4.769
	50 - 70 Yrs	39	4.666	.382	.0612	4.542	4.790
	Total	287	4.626	.447	.0264	4.574	4.678
Purchase Behavior MEAN	18 - 35 Yrs	144	4.201	.709	.0591	4.084	4.318
	36 - 49 Yrs	104	4.375	.599	.0588	4.258	4.491
	50 - 70 Yrs	39	4.555	.537	.0860	4.381	4.729
	Total	287	4.312	.659	.0389	4.235	4.389

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Purchase Intention MEAN	Between Groups	1.021	2	.510	2.581	.078
	Within Groups	56.172	284	.198		
	Total	57.192	286			
Purchase Behavior MEAN	Between Groups	4.488	2	2.244	**5.308**	.005
	Within Groups	120.053	284	.423		
	Total	124.541	286			

Descriptive Statistics (Age Groups Comparisons)

The impact of being an electric bill payer on the purchase behavior of LED products was also investigated by conducting a one-way ANOVA analysis. Respondents were divided into three groups: (1) Those who are responsible for paying electric bills regularly, (2) those who sometimes paid, and (3) those who have never paid. The results indicated a statistically significant difference in purchase behavior scores for the three groups, $F(3, 287) = 5.509$, $p = 0.001$. Post-hoc analysis using the Scheffe test showed that the mean score for Group 1 ($M = 4.43$, $SD = 0.60$) was significantly higher than the mean scores reported by both Group 2 ($M = 3.91$, $SD = 0.66$) and Group 3 ($M = 4.16$, $SD = 0.71$). However, Group 2 did not significantly differ from Group 3 (Table 4.13).

Table 4. 13 Electric Bill Payer Groups Comparisons – ANOVA and Post Hoc using Scheffe

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Purchase Intention MEAN	Between Groups	1.716	3	.572	2.921	.034
	Within Groups	55.616	284	.196		
	Total	57.332	287			
Purchase Behavior MEAN	Between Groups	6.875	3	2.292	5.509	.001
	Within Groups	118.137	284	.416		
	Total	125.012	287			

Descriptive Statistics (Electric Bill Payer Comparisons)

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Purchase Intention MEAN	Unreported	2	4.666	.471	.333	.431	8.902
	Paid Some Months	15	4.466	.394	.101	4.248	4.685
	Paid Regularly	174	4.687	.410	.031	4.626	4.749
	Never Paid	97	4.543	.500	.050	4.442	4.643
	Total	288	4.627	.446	.026	4.575	4.679
Purchase Behavior MEAN	Unreported	2	4.333	.471	.333	.097	8.568
	Paid Some Months	15	3.911	.660	.170	3.545	4.278
	Paid Regularly	174	4.431	.600	.045	4.341	4.520
	Never Paid	97	4.168	.717	.072	4.023	4.312
	Total	288	4.314	.659	.038	4.238	4.391

Post Hoc Comparisons using Scheffe Test (Electric Bill Payer Groups)

Dependent Variable	(I) E-Bill payers [Recode]	(J) E-Bill payers [Recode]	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval
						Lower Bound
Purchase Intention MEAN	Unreported	Paid Some Months	.200	.333	.948	-.736
		Paid Regularly	-.021	.314	1.000	-.906
		Never Paid	.123	.316	.985	-.765
	Paid Some Months	Unreported	-.200	.333	.948	-1.136
		Paid Regularly	-.221	.119	.330	-.556
		Never Paid	-.076	.122	.943	-.421
	Paid Regularly	Unreported	.021	.314	1.000	-.864
		Paid Some Months	.221	.119	.330	-.113
		Never Paid	.144	.056	.086	-.012
	Never Paid	Unreported	-.123	.316	.985	-1.012
		Paid Some Months	.076	.122	.943	-.269
		Paid Regularly	-.144	.056	.086	-.302
Purchase Behavior MEAN	Unreported	Paid Some Months	.422	.485	.860	-.943
		Paid Regularly	-.097	.458	.997	-1.387
		Never Paid	.164	.460	.988	-1.130
	Paid Some Months	Unreported	-.422	.485	.860	-1.787
		Paid Regularly	-.519*	.173	.031	-1.008
		Never Paid	-.257	.178	.559	-.760
	Paid Regularly	Unreported	.097	.458	.997	-1.192

		Paid Some Months	.519*	.173	.031	.031
		Never Paid	.262*	.081	.017	.032
	Never Paid	Unreported	-.164	.460	.988	-1.460
		Paid Some Months	.257	.178	.559	-.246
		Paid Regularly	-.262*	.081	.017	-.492

Summary of Hypotheses Testing

Hypotheses	Description(s)	Results
H1	Attitude towards LED products is positively associated with Purchase Intention towards LED products	**Supported**
H2	Subjective Norm is positively associated with Purchase Intention towards LED products	**Supported**
H3	Perceived Behavioral Control is positively associated with Purchase Intention towards LED products	**Supported**
H4	Purchase Intention is positively associated with Purchase Intention towards LED products	**Supported**
H5	Perceived Behavioral Control is positively associated with Purchase Behavior towards LED products	**Supported**
H6	Attitude towards LED products is positively associated with Purchase Behavior towards LED products	**Supported**
H7	Purchase Intention mediates the relationship between Attitude and Purchase Behavior	Not Supported
H8	Purchase Intention mediates the relationship between Subjective Norm and Purchase Behavior	Not Supported
H9	Purchase Intention mediates the relationship between Perceived Behavioral Control and Purchase Behavior	Not Supported

4.1.4. Discussion of Results

Overall, the results confirm that the TPB model and its measures were suitable for this study group. Attitude has been highlighted as the strongest predictor of the purchase intention of LED products. H1 suggested a positive association between attitudes and purchase intention. The result was in line with the TPB model from previous studies (Tan et al., 2017); (Ali et al., 2019; Hua & Wang, 2019). With an attempt to support future purchases of LED products, policymakers should focus on encouraging green attitudes by creating a favorable image regarding the usefulness of LED products in terms of what they can bring to the wider public.

Subjective norms, according to this study's results, were the weakest determinants of purchase intention towards LED products. H2 indicated that a consumer's subjective norm was positively associated with purchase intention towards LED products. This result is in accordance with one of previous findings of the TPB studies by (Armitage & Conner 2010), which found that subjective norm was the weakest predictor and attitude had the largest direct effect on purchase intention. Subjective norms being the weakest determinants among other variables implies that Thai household consumers would not be significantly affected by advice from other individuals around them on their decisions to purchase LED products.

PBC has a strong direct influence on purchase intention towards LED products. H3 proposed a positive relationship between consumers' perceived behavioral control and their purchase intentions towards LED products. This result is consistent with findings in the literature (Ali et al., 2019; Hua & Wang 2019). Furthermore, the results also show that PBC was found to have a direct influence on purchase behavior related to LED products. H5 suggested a positive association between PBC and purchase behavior towards LED products; this hypothesis was supported ($\beta = 0.232$, $p < 0.001$). The result was in line with those in previous literature (Ali et al. 2019); (Han, Hsu, & Sheu, 2011). The main impact of PBC is that when individuals are more confident on their capacity to purchase, they are more likely to purchase products. In this regard, policymakers should make sure that when consumers are making purchase transactions,

clear and reliable information on the benefits of LED lighting products must be available to them. Effective information is of great importance for their decision-making process, which assures their confidence and capacity to purchase such products.

Purchase intention was found to have a significant influence on purchase behavior in relation to LED products. H4 predicted that purchase intention was positively associated with purchase behavior around LED products. The finding was in line with those of previous studies (Yadav & Pathak 2017; Chaudhary & Bisai 2018). Since purchase intention was found to be an important determinant of purchase behavior towards LED products, it is vital for green marketers or policymakers to put more effort into improvements of the three main variables in the proposed model, i.e., attitude, subjective norms, and perceived behavioral control.

This study highlights the significant and direct relationship of attitude and purchase behavior, even when purchase intention is presented into the model. H6 was supported ($\beta = 0.154$, $p < 0.003$). The findings of a significant and direct relationship between attitude and purchase behavior is in accordance with previous studies by (Fazio, 1995), which found theoretical arguments and statistically significant correlations between attitude and purchase behavior. Based on the constructs of "Attitude" in this survey, the questionnaire constructs mainly captured the respondent's evaluation of their previous experience with an object. More importantly, the researcher selects only respondents who have previous experience with LED products. As such, the implication from (Fazio, 1995) is that attitudes based on direct behavioral experience with an object should be (1) more accessible in the sense that the evaluation times to respond to questions about these attitudes should be quicker; and (2) more predictive of actual behavior toward that object. Therefore, attitudes that were retrieved from the respondents' memory rapidly and easily is more likely to be activated whenever the attitude object is presented.

There were significant differences between age groups and status as an electric bill payer in relation to purchase behavior relating to LED products. The results suggest that older people might have more time or put more effort into selecting home products

that are more efficient to reduce household expenditure. However, the results contradicted those from a number of previous studies (Howell & Laska, 1992; Linden et al., 2006; Torgler et al., 2008), which argued that younger individuals tend to prefer up-to-date technology and are more willing to pay for environmental protection than older generations. A possible explanation is that the previous studies were conducted more than 10 years ago, when information and communication channels were not ubiquitously distributed. However, older generations nowadays gain access to updated technology and knowledge about energy-efficient measures much faster than older generations from previous studies. In terms of bill paying behavior, differences were found between those who were responsible for paying electricity bills regularly and those who sometimes and/or never paid the bills in relation to their reported purchase behavior towards LED products. A possible explanation is that those who paid electric bills regularly would witness an increase in household energy expenditure and might seek useful energy-saving tips, in which adopting energy-efficient lighting products would serve as a solution to reduce energy costs at home.

This study's findings highlight several implications which might help in developing practical strategies or sound policy recommendations for eco-friendly products or energy-efficient products like LED bulbs. With attitudes exerting the strongest impact, policymakers/marketers should attempt to attract more consumption by using promotions and infomercials which trigger consumers' attitudes towards energy-saving possibilities as well as increasing environmental awareness. As such, policymakers should provide consumers with more product accessibility and more direct behavioral experience with LED products, in the sense that in the future it will be more quickly, automatically, and easily retrieved from memory and past experience.

Practically, the government, entrepreneurs, or the private sector should develop public interventions to enable faster decision-making while showcasing how the consumption of LED products could help reduce individual energy expenditure at home as well as reduce adverse environmental impacts at a wider scale. In this regard, a modern approach for green marketing should raise awareness of the importance of energy-efficient products' benefits, referring to such benefits as always being available

to customers, particularly when they are making purchase transactions. For instance, the availability of shelf display information of the LED products' benefits as well as eco-labelling at the point-of-sale would signal green consumption behavior and reduce search costs for more energy-efficient options. Furthermore, as more than 74% of the Thai population own a smartphone and have access to the Internet, the government should see this as an opportunity to cultivate green attitudes, disseminating LED products' benefits to the general public through various online channels to help make it a social norm. As such, the importance of LED products' benefits being "omnipresent" would encourage brands to create strategies for individual channels including retail, social media, and modern E-commerce applications.

4.2. Behavioral Anomalies influencing the Purchase of LED products

4.2.1. Descriptive Statistics

The respondents in this study were only those who have never adopted LED products at home (i.e., non-LED users). Total 181 respondents were used for data analysis in this study. Table 4.14. below shows the descriptive statistics of respondents in this study.

Table 4. 14 Summary of sample (Non-LED users)'s socio-demographic and household characteristics (n=181)

Category	Frequency	(%)
Gender		
Male	96	53%
Female	85	47%
Age		
Gen Y (18–35 years)	85	47%
Gen X (36–49 years)	76	42%
Baby Boomers (50–70 years)	20	11%

Education Level		
Lower than Bachelor's	22	12%
Bachelor's	118	65%
Higher than Bachelor's	38	22%
Other	3	1%
Residence		
Bangkok	134	74%
Other	47	26%
Household Income		
Low Income (0–25,000)	29	17%
Middle Income (25,000–75,000)	94	52%
High Income (75,000–100,000+)	58	33%
Home Ownership		
Owned	155	86%
Rent	26	14%
Family Member		
Small HH (1–3)	85	47%
Medium HH (4–6)	67	37%
Large HH (7–10+)	29	16%

HH, household. Source: Author's own calculation.

4.2.2. Behavioral Anomalies towards purchasing LED products

In this section, non-LED respondents were asked about what are some behavioral anomalies towards purchasing LED products. The following consumers' perception of behavioral anomalies towards purchasing LED products were repeatedly emerged during preliminary interviews. These anomalies can be classified into three main factors, i.e., behavioral factors, price factors, and technical factors – as encapsulated in the following excerpts (Table 4.15). These factors derived from preliminary study will also be included in the main survey instruments in order to further investigate the results in a larger parent study. After that, they were tested about

their perceived knowledge of LED's benefits, and their motivations to buy LED products for their future purchase transactions.

The results from preliminary interviews suggest that there are many reasons other than what this research expected which impede their decisions to purchase LED light bulbs. Some important reasons are related to knowledge about the characteristics about LEDs. For example, some respondents did not know about the benefits of using LED bulbs, even though they wanted to change to LEDs. Also, they did not see major differences of using LEDs at home, therefore, they kept buying the same types of light bulbs. These are some important examples of how these factors act as barriers to adopt LED products.

Table 4. 15 Consumers' Perception of Behavioral Anomalies (Preliminary Interview)

Factors	**Perceived Barriers to adopt LEDs**	**Conceptual Terms**
Behavioral Factors	- I have used only these types of bulbs (not LEDs), and I don't want to change anything - I have used only CFLs and Incan / Never used LED bulb before / habits of buying the same bulbs	Habits
	- The current bulb is still working - There is no need to replace - I will wait until the old ones finished	Endowment Effects or Sunk Costs
	- The current lighting products are not LEDs, so I will continue to use the same products the next time I buy them - I always buy the same type of bulb currently in use at home	Status Quo Bias
	- I am satisfied with the current bulbs I have; don't want to become more energy-efficient at home - I am satisfied with the current bulb I used	Satisfice

	- Don’t care about payback period of LED products - Look at the purchase price only - I concern about the price, rather than its efficiency - Don’t care about long-term energy costs	Time Inconsistent Preferences
	- LED product do not meet my demands (e.g., dimmability, pet heating from lamp) - LED bulb is not durable / does not fit my purpose - I see no major differences of adopting LEDs at home - Don’t trust in LED technology and its energy-efficiency - I don’t care about lighting in my house	Personal preferences
	- I can’t find LED bulb easily in my local area	Availability Bias
Price Factors	- Price of an LED bulb is too high, can’t afford	
Technical Factors	- LED bulb is not dimmable	
	- If changed to LED, the light volume (illuminance) will change as well	
	- Do not know about LED products - Want to change, but have no knowledge about LED products	Knowledge Gap

These factors from preliminary interview were included in the main survey instruments in order to recheck the validity and reliability of the results. Table 4.16 described the survey results of behavioral anomalies towards adopting LEDs. From table 4.16, the top three main reasons for those who did not choose LED bulbs are; 1.) they were satisfied with the current bulb and its energy-efficiency potentials, 2.) They previously have bought only CFL/Incandescent types, and 3.) They always buy the

same bulb currently at home. Whereas the least mentioned reason was “LED bulb is hard to find in my area” indicating that LED bulbs were easily available for sale in their local areas - which had no effects on their decisions to purchase a light bulb.

Table 4. 16 Behavioral Anomalies towards Purchasing LED Products (Survey)

Behavioral Anomalies	**Frequencies**
I am satisfied with the current bulb I used (Satisfice)	57
LED bulb is not durable / does not fit my purpose (Personal Needs)	17
I concern about the price, rather than its efficiency (Time-Inconsistent Preferences)	19
Buy the same type of bulb currently in use at home (Status Quo Bias)	51
The current bulb is still working / No need to replace / Wait until the old ones finished (Endowment Effect or Sunk Costs)	36
LED bulb is far more expensive (High Price Factors)	40
I have used only CFLs and Incan / Never used LED bulb before / habits of buying the same bulbs (Habits)	52
LED is hard to find in my area (Availability Bias)	16
I see no major differences of adopting LEDs at home	23

4.2.3. Knowledge Gap in LED Product Adoption

According to the preliminary interview, knowledge about LEDs appeared to be one of the most mentioned reasons for non-LED users not to adopt LED products. This study aimed to test the knowledge of LED benefits in order to understand what information consumers did not know about. The author considers this result to be useful for better providing consumers with the accurate information they are lacking. The benefits of LED products that were tested in the survey were mainly derived from (IEA, 2019). Figure 4.2 illustrated the knowledge of non-LED users on the benefits of LED products given in the survey, most of them realized that "LED bulb has the highest energy-saving potentials". While the majority of them don't know that "LED bulb has the shortest payback period", followed by "LED bulb is environmentally-friendly".

Since majority of samples did not know about the information "LED bulb has the shortest payback period", the author further investigated the results by observing their decisions when the payback period information was given in the light bulb choices. The payback period of investment in energy-efficient products refers to the time it takes for the energy-saving potentials to payback the initial cost of the investment. This method has been widely used to evaluating project's financial feasibility and estimating energy-savings. This study argues that consumers did not know about the long-term energy-saving potentials of LED bulbs probably because the payback period information was not available during their purchases.

Previous studies suggested that effective interventions should connect consumers with their 'future selves' which lead to larger contributions to savings and future rewards (Hershfiled et al., 2011); (Gill, Atlas, & Hardisty, 2016). This implies that future rewards from consumers' purchase decisions should be available to them. Hence, the next questionnaire related to the previous question (Table 4.17) is that - when the payback period was presented in terms of the long-term benefits of all types of bulbs, which types of light bulbs consumers may choose for their future purchase if these long-term benefits were given during purchase transactions? The results show that 86% of non-LED users convert to LED bulbs for their next purchase especially

when the long-term energy-saving benefits were included in their product choices (see Figure 4.3).

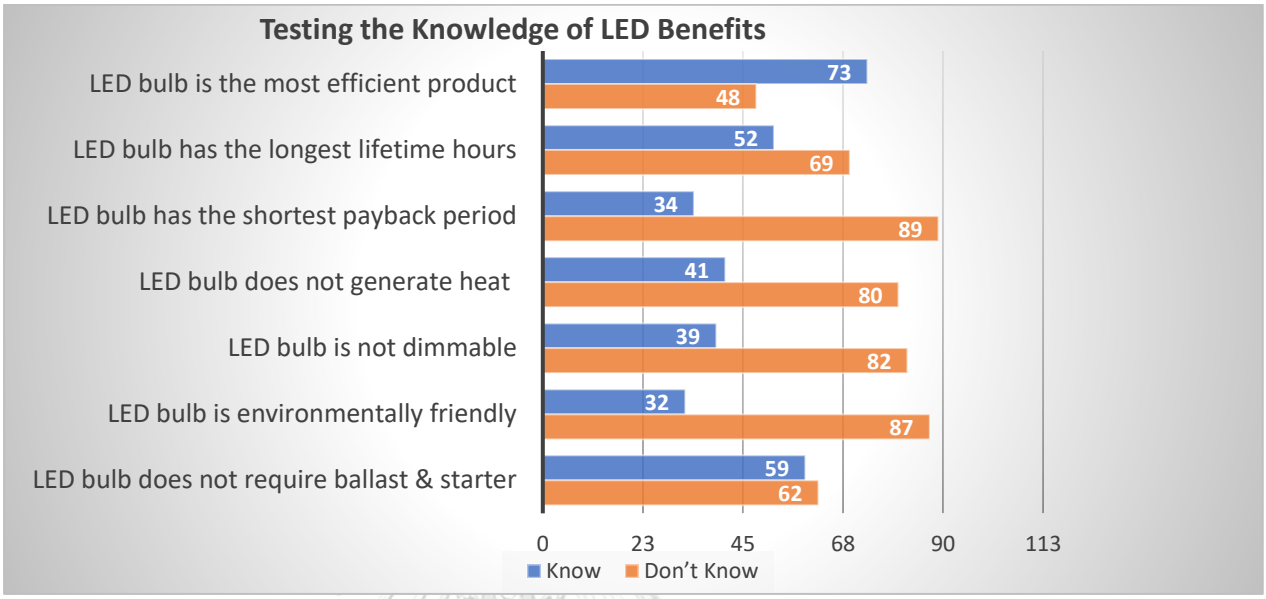


Figure 4. 2 Respondents' Perceived knowledge of LED Benefits

Table 4. 17 Questionnaires related to the long-term energy costs of all types of light bulb

Incandescent	Compact Fluorescent Lamp (CFL)	Light-Emitting Diode (LED)
		
[01] PRICE: 25 THB WATT: 60W LIFETIME Hrs.: 1,200 Hrs. **E-COST/Year: 985 THB/Year**	[02] PRICE: 74 THB WATT: 14W LIFETIME Hrs.: 8,000 Hrs. **E-COST/Year: 242 THB/Year**	[03] PRICE: 148 THB WATT: 8W LIFETIME Hrs.: 25,000 Hrs. **E-COST/Year: 138 THB/Year**

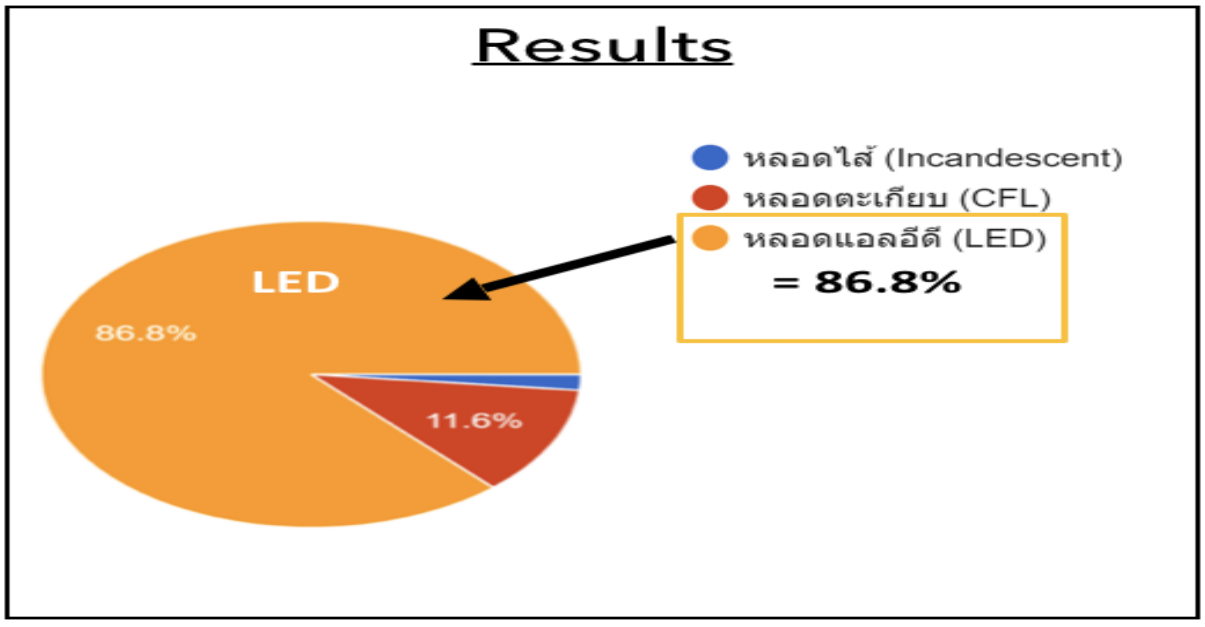


Figure 4. 3 Results from the questionnaire regarding the long-term energy costs of light bulbs.

4.2.4. Discussion of Results

This research attempted to investigate consumer's perception towards purchasing LED products by investigating behavioral anomalies as barriers to adopt LEDs, testing their knowledge of LED's benefits, and examining behavioral interventions based on the results from this study. A number of interesting points were found in this present study, as follows;

Results revealed that the major behavioral anomalies to adopting LED bulbs at home were their (1) current satisfaction with the previous (inefficient) light bulbs and (2) habits of buying the same light bulb types, i.e., those recently adopted at home. This implies that consumers are reluctant to change to more energy-efficient options mainly due to their personal satisfaction, habits, and status quo bias. This situation can be explained by previous studies showing that – when choosing amongst a variety of options, consumers might be prone to the first satisfactory option they currently have, rather than the best options for themselves and the public (Simon, 1956); (Kahneman, 2003). In like manner, the insights from psychology tell us that our brain is wired to take shortcuts, and prioritizes quick and satisfactory decision making, over thoroughly considered and conscious options (Frederiks, Karen, & Hobman, 2015, pp. 1385–1394; Iyengar & Lepper, 2000).

With respect to satisficing factor, policymakers should draw attention to designing a desired action quicker, simpler and easier to perform the actions (e.g., default settings, automatic technology, or generating risk-free environment) (Schultz, 2014); (Vermeir & Verbeke, 2006). Keeping consumer-focused messages short and simple is important for efficient communication, rather than presenting with too many energy-saving tips or too many choices. On the other hand, overcoming habits and status quo bias might require behavioral interventions related to energy-efficient measures which are effortlessly adapted or easily modified. A number of studies have proved effectiveness of the "default setting" interventions in various energy-efficient appliances (McCalley, 2006; Schultz, 2014). Alternatively, offering 'free trial' or 'try before you purchase' campaigns such as "Lightbulb Exchange Programs" (Salt Lake

City, USA, 2019), or the “LED bulb Free Trial Campaigns” at The City of Red Deer (Canada and Fairfax County in 2018)” - would trigger their decisions, so that people are more amenable to change (Verplanken & Wood, 2006).

Interestingly, when those non-LED users were asked about the LED’s benefits given in the survey, most of them realized that “LED bulb has the highest energy-saving potentials”. While the majority of them don’t know that “LED bulb has the shortest payback period” and “LED bulb is environmentally-friendly”. This study argues that during purchase transaction of light bulbs, only the energy-saving benefits were labelled at the product packages, however, such environmental benefits as well as comparative payback periods were not presented. It is, therefore, not surprised with the outcomes, yet important to note that product label and package plays a significant role in communicating with consumers and effectively influencing their purchase decisions.

Based on the results from the previous question, i.e., that most of them do not know that “LED bulb has the shortest payback period” being the least motivators to purchase LED bulbs from the perspective of non-LED users. The researcher then attempted to emphasize the benefits of LED in terms of payback period by including the long-term energy costs of all bulb types in the light bulb choices they required to choose in a survey questionnaire. The results show that almost 90% of non-LED users, when they see the long-term benefits of all different bulb types, decided to choose LEDs for their next purchase transactions. Hereby, payback period of LEDs, when presented properly during the purchase, can effectively motivate consumers to make more efficient options. Policymakers, governments, or private sectors should pay more attention to some of these LED benefits (such as payback period, or environmental friendliness) by introducing them with information that contain explicit energy-saving benefits of LED bulbs in comparison to the current bulbs they used.

4.3. Price Perception of LED Products

Results of the price curves and their intersections for each product category are discussed in this section. The price range between Price of Marginal Expensiveness (PME) and Price of Marginal Cheapness (PMC) is considered as a suitable price range, where most of the products are commonly price within this range (Roll, Achterberg, & Herbert, 2010). The Optimal Price Point (OPP) is the price that producers expect to increase the demand for their products, which in turns, generate their profits. Since the main objective of this research is to compare the PSM results of LED products, this research creates two price plots for the two different categories of respondents (i.e., LED users vs. non-LED users). The difference between the two groups shows consumers' perception of the price of the LED bulb.

Prior to data analysis, some respondents with inconsistent price preferences (i.e., answer "cheap price" question larger than "expensive price" question", or their answers were either extremely cheap or expensive) were removed from the data set. The PSM function has its built-in function to detect extreme outliers and invalid preferences; which were removed from the analysis by default. The sample consisted of total 469 respondents; where 288 were LED respondents and 181 were non-LED respondents.

4.3.1. Comparison of PSM Results (LED Users vs. Non-LED Users)

Table 4.18 shows the price points collected from LED users, and Table 4.19 shows the price points of non-LED users. It shows that an equal amount of LED respondents believe 80 THB is "too cheap" and "not a bargain" – indicating the "Point of Marginal Cheapness" (PMC). For non-LED respondents, their PMC equals to 70 THB – slightly lower than the PMC of LED respondents by 10 THB. At these price points (80 THB and 70 THB) - indicated the lowest price of an LED bulb which should be charged, while lower prices than these would be perceived as lacking in quality.

The second key data point is the intersection of “too cheap” and “too expensive”, which was defined as “Point of Marginal Expensiveness” (PME). It indicated the maximum price which should be charged for an LED bulb, while higher prices than PME suggested that extremely low respondents would accept these prices. In this study, the PME for LED users is at 200 THB, suggesting the highest price where majority of respondents would accept the cost of purchasing an LED bulb. On the other hand, the PME of non-LED users equals to 180 THB, again, slightly lower than the PMC of LED respondents by 20 THB.

The range of price points from PMC to PME indicates an acceptable price range of an LED bulb. The analysis concludes that the acceptable price range for LED users to purchase an LED bulb is from 80 THB – 200 THB. The price point where “not a bargain” and “not expensive” lines intersect each other is called the “Indifference Price Point” (IPP). The IPP is defined as the point at which the number of customers who feel it is a bargain and those who feel that it is too expensive are equal. The IPP for LED users is at 145 THB. In comparison, an acceptable price range for non-LED users is at 70 THB – 180 THB, and the IPP equal to 120 THB.

The last key price point is the intersection of “too cheap” and “too expensive”, which was often referred to as the “Optimal Price Point” (OPP). OPP is when the same percentage of respondents feel that the price is “too expensive” versus the perceived quality of an LED bulb. It is argued to be the best price spot within the acceptable price range as it allows businesses or policymakers to make pricing decisions. In this study, the OPP for LED users equal to 120 THB, while the OPP for non-LED users are at 100 THB.

Table 4. 18 Price Threshold of LED Users (n=288)

Indifference Price Point (IPP)	THB145
Optimal Price Point (OPP)	THB120
Acceptable Price Range	[THB 80 , THB 200]

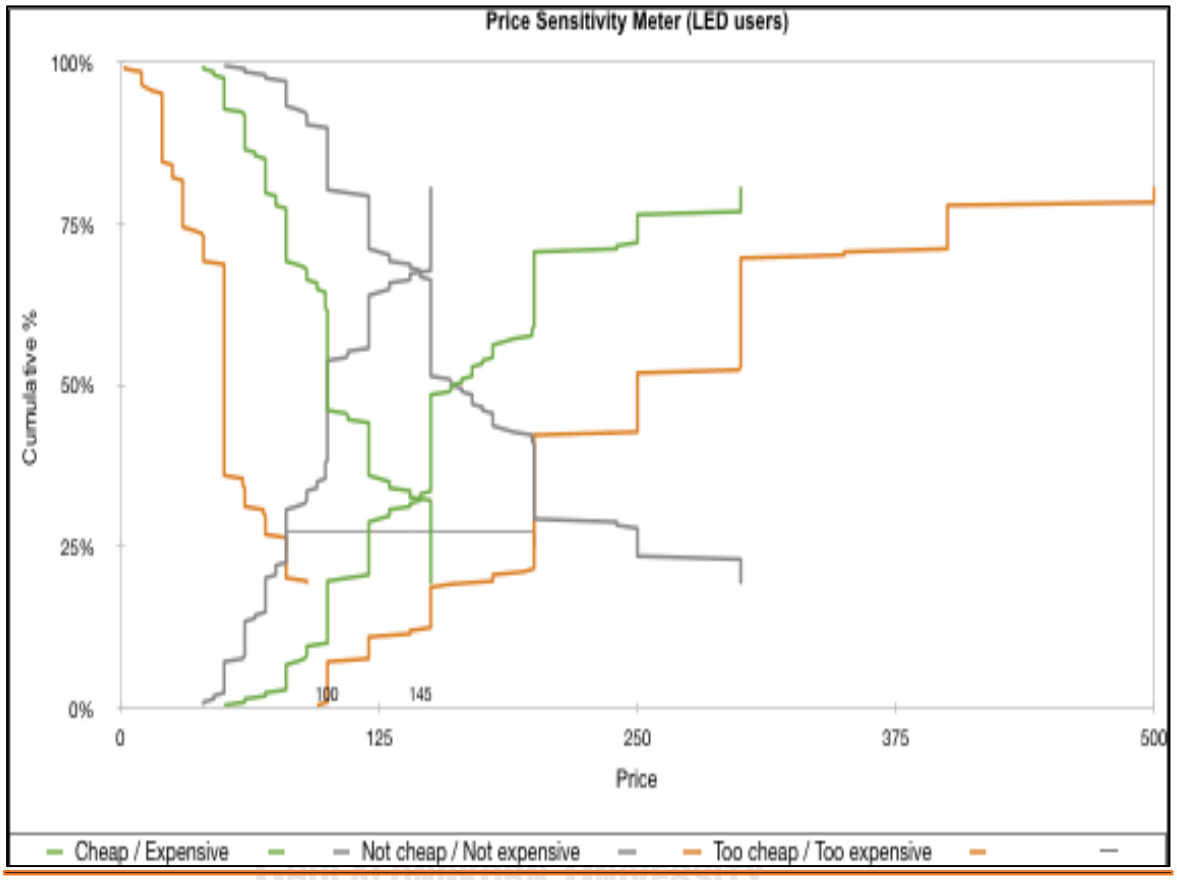


Figure 4. 4 Price-Sensitivity Measurement of Participants (only LED users)

Table 4. 19 Price Threshold of Non-LED Users (n=181)

Indifference Price Point (IPP)	THB120
Optimal Price Point (OPP)	THB100
Acceptable Price Range	[THB 70 , THB 180]

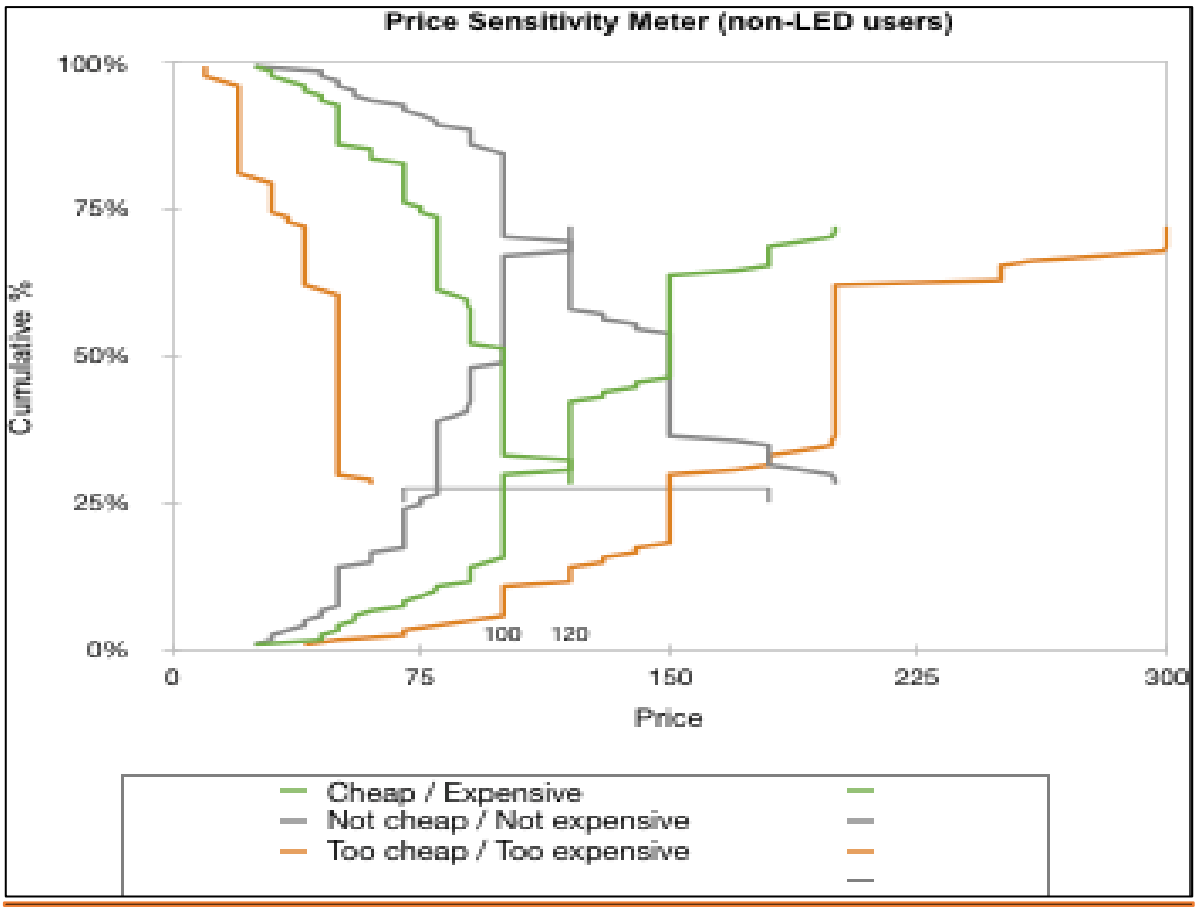


Figure 4. 5 Price-Sensitivity Measurement of Participants (only non-LED users)

Since the aim of this research is to determine how different consumer groups price an LED bulb, it is expected that the difference between OPP (LED users) and OPP (non-LED users) will describe how these two groups perceived the price of an LED bulb differently. The difference in the OPP (120 – 100 = 20 THB) is the price that consumers are willing-to-pay for adopting energy-efficient products, which signal their willingness-to-pay the premium for green products like LED bulbs. In other words, LED users are willing to pay more than non-LED users in adopting an energy-efficient LED bulb by 20 THB. The results met the authors' expectations that a person who has

never used an LED bulb before, or who is unaware of the quality of LED bulb tends to understate the product. The difference of OPP among the two groups (20 THB) would show the value of the energy-efficiency of an LED bulb over the normal bulb.

4.3.2. Combined Results of PSM Analysis

Figure 4.6 illustrates the PSM curve of both LED respondents and non-LED respondents combined, and Table 4.20 shows their price points. If the survey respondents were pooled together, its OPP would be at 100 THB. At this price point, LED users would definitely purchase it, since the price is even lower than their OPP of 120 THB. Non-LED users would also purchase at this price as their OPP is the same at 100 THB. Therefore, by setting the optimal price point at 100 THB per bulb, both LED users and non-LED users would purchase the product. The IPP represents the median price or the price indicating one of the products from leading brands (i.e., PHILIPS is the market leader of light bulb market in Thailand). An acceptable price range of an LED bulb in general consumers' point of view is at 80 – 200 THB. In market that are already well-established; few competitive lighting products would be priced outside this price threshold. In addition, this study compared the perception of price points of LED products from the empirical findings to the actual retail prices of LED products in variation of Watts. The current retail price of PHILIPS brand ranging from a 5W LED @89 THB to a 19W LED bulb @195 THB (Date: 22 July 2020). Interestingly, the price point results were aligned with the current retail prices of LED bulbs from PHILIPS brand. The optimal price of LED bulb at 100 THB can be referred to the actual retail price of a 10W LED bulb (@ 99 THB/bulb).

Table 4. 20 Price Threshold of both LED Users and Non-LED Users (n=469)

Indifference Price Point (IPP)	THB120
Optimal Price Point (OPP)	THB100
Acceptable Price Range	[THB 80 , THB 200]

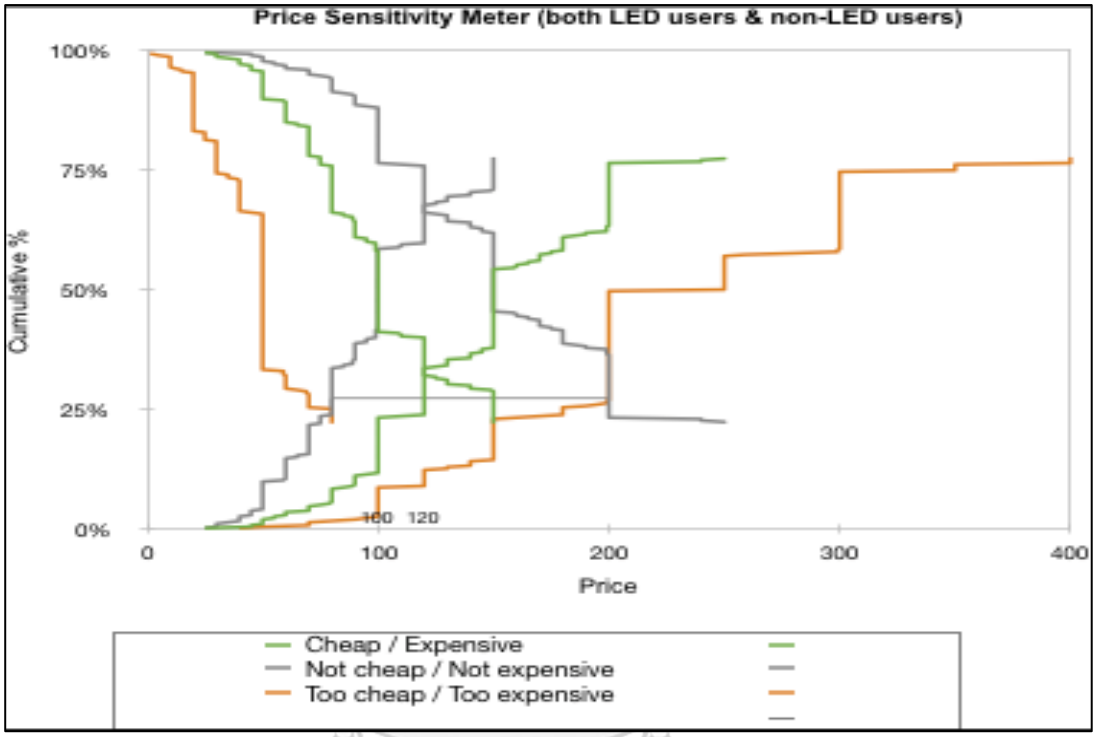


Figure 4. 6 Price-Sensitivity Measurement of Participants (Combined)

Overall, the results confirm the initial expectations that the OPP (LED users) would be higher than OPP (non-LED users). The difference in the optimal price points is the price that LED users are willing to pay for premium of an LED bulb, which also assess the energy-efficiency potential of the product itself. The application of PSM allowed researcher to differentiate the optimal prices across the two different light bulb users and define the additional costs to pay for energy-efficient lighting products as perceived by consumers in Thailand.

4.3.3. Discussion of Results

This study's empirical research has described the applicability of the PSM in determining the optimal prices intended to promote the adoption of LED bulbs by differentiating the OPP assessed by the common sample of respondents into OPP (LED users) and OPP (non-LED users). This differentiation of respondents implies that it is possible to assess the optimal price points for each group and understand to what extent consumers value eco-friendly products like LED bulbs. The results of this research found the discrepancy between optimal prices across two different groups accounts for the incorporated willingness-to-pay (WTP) for premium towards energy-efficient products. The results met the expectations that LED users value the product higher due to their previous direct experience of the product's efficiency, than those who have never experienced the product's efficiency in energy-saving. The price difference between these two groups would suggest the perceived benefit of an LED bulb over the normal bulb in the market.

The results from investigating consumer's perceptions towards the prices of an LED light bulb using the PSM analysis were useful for policymakers in adjusting pricing policies to target different consumer groups, particularly current LED users and non-LED users. The analysis of PSM allows policymakers to articulate on the IPP and OPP of an LED bulb in Thailand's light bulb market. In other words, these price points allow policymakers to identify which price point is more likely to generate a maximum sale volume of an LED bulb, which can substantially increase the total adoption of LED products in Thailand.

In spite of valuable insights from the PSM analysis, this study confronts some limitations which require further research. Firstly, PSM only asks about price of a single product in isolation from other characteristics of the product and the analysis for a wider energy-efficient product line. The future research should focus on investigating WTP the premium for wider energy-saving products, instead of taking only one product line. A number of previous literatures have incorporated consumers' WTP for several green products (Biswas & Roy, 2016); (Kucher, Hełdak, Kucher, & Raszka, 2019) and various ecological products (Canavari, Nocella, & Scarpa, 2003); (Leszczyńska, 2014).

Extending the analysis for a wider range of green products would allow us to define optimal prices across a lager consumer profile. Secondly, PSM analysis is often criticized as a “direct” pricing technique where respondents are prone to underestimating their actual price perceptions. As such, future studies should combine PSM results with more quantitative analysis (e.g., regression analysis, conjoint analysis, etc.), which might help researchers or policymakers to increase the predictive quality of the price points in a wider range of circumstances.

CHAPTER 5 CONCLUSIONS

5.1. Summary of Findings

This thesis has examined purchasing behavior of LED lighting products of Thai consumers by focusing on three aspects including; factors affecting purchase behavior of LED products, behavioral barriers to purchase these products, and consumers' perception of prices towards LED products. This conclusion section aims to summarize the specific studies undertaken, conclusions, theoretical contributions, and their policy/managerial implications.

In order to understand behavioral and psychological theory related to purchase behavior of energy-efficient products, it attempted to investigate the factor affecting their purchase behavior towards LED products by applying the Theory of Planned Behavior as the main theoretical framework. No research efforts have been made in the last five years to examine LED products in Thailand. To fulfill this research gap, the first research objective is to empirically investigate purchase behavior related to energy-efficiency in the context of LED lighting products among Thai consumers. This study explored the relationship of factors, examined the effects of socio-demographic variables (age, gender, income, and some purchase characteristics), and purchase behavior towards LED products. Empirical findings regarding the TPB determinants were discussed, followed by the findings associated with socio-demographic variables.

All of the main determinants from Ajzen's Theory of Planned Behavior (attitude, subjective norm, perceived behavioral control) were found to have positive relationship with purchase intention, showing statistically significant at varying strengths. In addition, these three exogenous variables collectively explained 49.9% of the variance in purchase intention towards LED products. The main conclusion from

the theoretical analysis is that attitude was found to have the largest effect, whereas subjective norm was the weakest predictor of purchase intention. The study also found the direct influence from attitude to purchase behavior. An important additional finding of this study is that socio-demographic factors particularly age factors and status as being electric bill payer have significant effects on purchase behavior. However, gender, education level, household income, residence, and numbers of family members do not seem to have any relationship to individuals' purchase behavior of LED products.

In order to provide an understanding of energy-efficiency gap within contexts of purchasing LED products, this study reviewed the relevance of behavioral economics principles related to energy-efficient investment decisions. Principles from behavioral economics offered insights of certain behavioral anomalies as well as possibilities for bridging the "energy-efficiency gap" for the greater uptakes of LED products in Thailand. In contradiction to classical economic assumptions, consumers routinely deviate from rational choice models, they failed to align with their knowledge, attitudes, and fall short of maximizing personal benefits. In context of energy-efficiency, the phenomena of low adoption despite its large potential energy-savings are often influenced by certain behavioral anomalies.

To fulfill the second research objective, we address the question of what are behavioral anomalies influencing the purchase of LED products, and how behavioral economics can be used to explain the energy-efficiency gap and how to bridge the gap. Results revealed that the major behavioral anomalies to adopting LED bulbs at home were their (1) current satisfaction with the previous (inefficient) light bulbs and (2) habits of buying the same light bulb types, i.e., those recently adopted at home. Majority of respondents (i.e., consumers who are not familiar with LED products) do not know about the knowledge of LED benefits that; "LED bulb has the shortest payback period" and "LED bulb is environmentally-friendly". Lack of these types of information could become the least motivators to purchase LED bulbs from the perspective of non-LED

users. The researcher then attempted to emphasize the benefits of LED in terms of payback period by including the long-term energy costs of all bulb types in the light bulb choices they required to choose in a survey questionnaire. The results show that almost 90% of non-LED users, when they see the long-term benefits of all different bulb types, decided to choose LEDs for their next purchase transactions.

Regarding price analysis, this study addressed the importance of how prices of LED nowadays appeal to consumers, which in turns influence their decision-making processes. The LED market has witnessed a substantial decline in prices since 2015. To the best of author's knowledge, there is clearly a lack of literature focusing on investigating consumers' perception of prices of LED products. To catch up with continuous decline in LED prices, the third research objective is to understand how consumers nowadays perceived prices of LED products. Since prices of LED products are varied based on number of Watts and brands, this study applied the Price-Sensitivity Measurement (Van Westerndorp, 1976); the method is suitable for providing an estimation of the acceptable price range which potential buyers would be willing to pay by reporting their upper and lower price thresholds. The main benefit of PSM analysis is to investigate how consumers' perception of values are affected by the interaction of price and product quality

The originality of this study is that it considers two different groups of consumers: (i) consumers who are familiar with LED products (LED users); (ii) consumers who are unfamiliar with LED products (non-LED users). The initial expectation of this study is that LED users would value the product higher than non-LED users due to their previous direct experience of the products. The result identified the comparison of acceptable price threshold between LED users and non-LED users. The optimal price point (price where majority of consumers would accept at this price) of LED users are higher than non-LED users by 20 THB. This 20 THB difference indicated the willingness-to-pay (WTP) a premium of LED-users is higher than non-LED users perceived the product values. In context of energy-efficient products, the

WTP a premium could be termed as the special feature of an LED bulb over normal bulb in the market, i.e., its highest energy-saving potentials of the LED product.

When the data of different consumer groups were pooled together, the median price represented the price of the product of market leader (i.e., PHILIPS brand) was at 120 THB. An acceptable price range of an LED bulb in general consumers' point of views was at 80 – 200 THB. In market which are well-established; few competitive lighting products would be price outside this price threshold. In addition, this study compared the perception of price points of LED products from the empirical findings to the actual retail prices of LED products in variation of Watts. The current retail price of PHILIPS brand ranging from a 5W LED @89 THB to a 19W LED bulb @195 THB (Date: 22 July 2020). Interestingly, the price point results were aligned with the current retail prices of LED bulbs from PHILIPS brand. The optimal price of LED bulb at 100 THB can be referred to the actual retail price of a 10W LED bulb (@ 99 THB/bulb).

5.2. Theoretical Contributions

Our findings contributed to the existing literatures of energy-efficient product adoption in various ways. This study advanced the current research on LED products, particularly accounting for the changes in consumer behavior now that the prices of LED lamps are becoming increasingly competitive. It also attempted to examine the validity and applicability of the TPB framework among different demographics at a different point in time, when compared to past studies. The design of the measures of constructs was developed from recent energy-efficient product adoption behavior literatures and the scale has been shown to be a robust measurement. It strived to unravel the direct influence of the main determinants in the model on actual purchase behavior through exploring the direct relationship between attitude and behavior by proposing purchase intention as a mediating variable. Furthermore, it furthers the knowledge of the predictors of energy-efficient buying behaviors among consumers in

Thailand, which in turn supports green marketers as they formulate marketing strategies to promote sustainability.

Another important contribution of this study lies in the generalizability of its results for specific types of energy-saving home products. Previous literature relied on the concept of "macroscopic" scale by using the variation of energy-saving home product types (e.g., air-conditioners, washing machines, televisions). However, these results were not generally applicable, since some influencing factors may differ across various types of energy-saving home products. This study attempted to overcome the generalizability challenges by focusing on one specific type of energy-saving home product, i.e., LED lighting products.

The theoretical contribution from our behavioral analysis lies in the application of insights from behavioral economics in understanding LED adoption behavior. Traditional microeconomic theory assumes that individual decisions are based on costs and benefits evaluation in relation to available information and knowledge. They rationally seek to maximize utility and minimize costs. However, numerous studies in the context of energy-efficient investments suggested that people sometimes fail to align with their knowledge and fall short of maximizing personal benefits in their decision-making. For instance, there exists a phenomenon called "energy-efficiency gap" indicating seemingly low adoption of seemingly beneficial energy-efficient investments (Allcott & Greenstone, 2012; Frederiks et al., 2015). The energy-efficiency gap argues that individuals are rational but there are certain barriers/biases prevent them from making optimal decisions, thus adversely affecting on their decisions to invest in more efficient options. The result from this study suggests that consumers are in fact missing sufficient information, impeding them from acting rationally. In our case, we illustrated that absence of knowledge regarding the payback period of LED products act as important barriers to their purchase decisions of LED products in this study.

Our work feeds into the behavioral economics literatures related to green purchase behavior by addressing possible behavioral barriers in the context of energy-efficient lighting product adoption. With the aim to increase LED adoption, it is of critical importance for policymakers or green marketers to understand these barriers to purchase and to develop effective marketing strategies focusing on overcoming these behavioral biases. Hereby, understanding the energy-efficiency gap provides an important recommendation for government's behavioral interventions in the household sector of the effective alternative, and to ensure that sufficient information is available for consumers when they are making purchase transactions of energy-efficient products.

The contribution from our price analysis is that it addresses the lack of empirical evidence of perception of prices for LED products. The results show the alignment between their consumers' perception of prices and actual retail prices of LED products in Thailand's lighting market, which reflects the validity of the results in this study. In fact, LED users perceived prices of LED products higher than non-LED users because of their previous experience of using LEDs at home. Thus, an important contribution of this study is that it quantifies the difference between how LED consumers value the product and how non-LED consumers value the same product, providing green marketers and policymakers to develop specific support schemes as well as pricing strategies for encouraging the adoption of LED products among those who have never adopted the product before, i.e., non-LED consumers.

5.3. Policy & Managerial Implications

In several countries the well-known strategies to encourage the adoption of green products is to implement policy supports in the form of financial incentives (Sorrell et al., 2004). However, numerous support schemes for green products are often perceived as unnecessary burdens on government expenditures in which costs bypassed onto taxpayers. Since the prices of LED products are becoming increasingly competitive in the lighting market in Thailand, such products did not necessarily require financial incentives (e.g., subsidies, tax incentives) for the increase adoption; unlike other product innovation such as renewable technologies which are heavily dependent on support schemes in the form of subsidies or tax incentives.

This thesis argues that efforts should be made to increase the individual's contribution to society, rather than providing financial incentives to consumers, or any production subsidies to manufacturers. To support this argument, Abrahamse & Steg (2009, pp. 711-720) suggested that energy consumers are more likely to feel personally responsible to save energy if they believe that their energy consumption consequences negatively affect the environment and others. With an attempt to support future purchases of LED products, policymakers should focus on encouraging green attitudes by creating a favorable image regarding the usefulness of LED products in terms of what they can bring to the wider public and the environment.

Based on the study's results, subjective norms being the weakest determinants among other variables implies that Thai consumers would not be significantly affected by advices from other individuals around them on their decisions to purchase LED products. However, we should not neglect the usefulness of norms in promoting energy conservation practices. In fact, it is well-argued that humans follow other behaviors, make social comparisons, and conform to social norms or what is considered to be "good practices" or socially desirable.

For example, studies by Constanzo et al. (1996) and Allcott (2010) highlighted the importance of social diffusion and social influence in promoting energy conservation among their reference groups such as friends, families, and social

networks. In fact, these mentioned studies also suggested that an inter-personal information sharing can be more influential than traditional sources of information provision (e.g., media, marketing, education, campaigns, etc.) and it is more likely to influence behavior of information receivers because it tends to be more easily understood, perceived and critically evaluated.

Nevertheless, in order to promote the positive effect of subjective norms on consumers' purchase behaviors, policymakers should strengthen the social norms of energy-saving behaviors. This thesis argued that both online channels and inter-personal information are equally important to foster energy conservation. Nowadays, the environmental sector has embraced social media as the medium to support environmental campaigns and movements locally and globally. Social enterprises or environmental organizations might use social media channels to spread normative messages to either encourage specific behavioral changes, or generate public pressure for environmental protection. As more than 74% of the Thai population own a smartphone and have access to the Internet, the government should see this as an opportunity to cultivate green attitudes, disseminating LED products' benefits to the general public through various online channels to help make it a social norm.

With respect to behavioral barriers such as satisfice or status quo bias in LED adoption, policymakers should draw attention to designing a desired action quicker, simpler and easier to perform the actions, i.e., default settings, automatic technology, free trial, or generating risk-free environment (Schultz, 2014; Vermeir & Verbeke, 2006). Keeping consumer-focused messages short and simple is important for efficient communication, rather than presenting with too many energy-saving tips or too many choices. On the other hand, addressing these biases might require behavioral interventions related to energy-efficient measures which are effective for overcoming consumers' explicit beliefs about poor green product quality.

This study, therefore, suggested that behavioral interventions like "product trial" can help overcome such biases by allowing consumers to experience directly the performance quality of green products like LEDs at home. For instance, offering 'free

trial' or 'try before you purchase' campaigns such as "Lightbulb Exchange Programs" (Salt Lake City, USA, 2019), or the "LED bulb Free Trial Campaigns" at The City of Red Deer (Canada and Fairfax County in 2018)" - would trigger their decisions, so that people are more amenable to change (Verplanken & Wood, 2006).

Another way forward is that government or the Ministry of Energy could develop a clear and ambitious plan to phase out inefficient light bulbs through public campaigns. A number of Asian countries have formed policies to encourage replacing old (inefficient) light bulbs - particularly the traditional incandescent bulbs with more efficient ones. Examples include the "Tokyo's Lightbulb Switching Campaign" in 2017 (JFS, 2017) and the "Together Brighter-Kyrgyzstan Campaign" initiated by the United Nations Development Program in 2019 (UNDP, 2019). However, to fully phasing out traditional incandescent bulbs, policymakers need to make sure that LED bulbs can be a perfect substitution in all different conditions and purposes. The results of this study pointed out that some consumers who continued to use an incandescent bulb because it is dimmable and offers heat for pet habitat. Since an LED bulb does not contain heat and the prices of the LED bulb with dimmability function are extremely high, the need for R&D of LED product functions are required in order to suit with all lighting conditions and purposes.

An effective solution to address the habitual behavioral barriers regarding the adoption of energy-efficient products can be addressed through an introduction of an energy-efficiency label. This thesis recommended that energy-efficiency labels could play a vital role in influencing purchase decisions, particularly product choices. Energy-efficiency labels are essential for consumers to acknowledge the potential energy consumption of newly purchased appliances, while helping consumers to identify cost-effective choices.

Effective energy-efficiency labels should contain comprehensive information which guides consumers to be aware of making the right choices for themselves and the environment. A number of empirical studies reveal a significant positive effect of

energy-efficiency labels on consumers' choices for energy-efficient appliances (Dyer and Maronick, 1988; Sammer and Westenhagen, 2006; Shen and Saijo, 2009; Ward *et al.*, 2011). Most of which identified the difference in the effectiveness of various information disclosure formats on the labels, i.e., yearly operating costs, lifetime costs, or in the form of physical units in influencing consumers' decision making. For instance, a field study by Gill et al. (2016) shows that presenting consumers with long-term energy operating costs underneath the current energy-efficiency labels increase the proportion of more energy-efficient products as well as the salience of energy-efficiency. Similarly, Hardisty et al.'s (2017) results show that higher proportions of more energy-efficient products were chosen (from 12% to 48%) when the 10-year energy costs were displayed on the product labels. The main goal of the information disclosure on the energy-efficiency labels is to overcoming a phenomenon called "energy-efficiency gap".

Based on the result from this thesis, payback period information of LEDs, when presented properly during the purchase, can effectively motivate consumers to make more efficient options. Policymakers, governments, or private sectors should pay more attention to some of these LED benefits (such as payback period, or environmental friendliness) by introducing them with information that contain explicit energy-saving benefits of LED bulbs in comparison to the current bulbs they used. For instance, the availability of shelf display information of the LED products' benefits as well as energy labels at the point-of-sale would signal green consumption behavior and reduce search costs for more energy-efficient options. Similarly, information such as yearly operating costs of lightbulbs are useful to demonstrate how consumers' decisions to buy will affect energy use over a longer period of time. These could perhaps help bridge the "information gap" by comparing which lightbulb choices are relatively more efficient.

5.4. Limitations and Future Research Directions

Despite academic and policy contributions, there are some limitations in this study which must be acknowledged. Firstly, the sample collected was concentrated on young household consumers. Future research should target other age groups, which may provide new insights. Meanwhile, the majority of samples were Bangkok residents, which may cause some bias in the results. Other parts of Thailand should also be examined to expand and potentially re-affirm the findings. Considerations about the quality and evaluation of research data include validity and reliability. In other words, interpretation of results is useful if data are valid and reliable. However, the major concern lies in the external validity of this study is weak as we analyzed data from respondents on convenience sampling basis. It cannot result in a representative sampling; therefore, it is quite hard to generalize our results to the whole lighting market.

Secondly, consumers' purchasing behavior can be affected by various factors other than those mentioned in this study. Future research should include some new factors, such as environmental knowledge, as new variables for an extended TPB framework, or provide qualitative approaches in order to construct a more comprehensive understanding of LED product purchase behavior. For instance, researchers may further develop the qualitative findings of the main behavioral barriers to the adoption of LED bulbs in this present study. On the other hand, researchers may include some risks associated with LED products, such as health or economic risks (Nguyen & Peña-García 2019). As consumer behavior is too complex to be explained by one overarching theoretical framework, future research directions should find a balance between its theoretical generality and behavioral patterns intended to investigate. Nevertheless, this study acts as a good starting point to further explore individuals' behavior towards energy-efficient products like LED bulbs, which could be applied to other types of energy-efficient products when consumers are faced with different choices of energy-efficient options.

This research has shown the usefulness of applying key principles from behavioral economics to describe and change consumer behavior in purchasing energy-efficient products like LEDs. However, some limitations regarding the method of online survey in understanding their actual decisions should be acknowledged. If the goal for applying behavioral economics principles is to understand people's actual decisions and biases, we might not obtain such actual reactions by simply asking people, in surveys, what they think would influence their decisions. In fact, behavioral economics is deeply rooted in empirical findings by making more accurate predictions of field phenomena. Further research should consider more suitable methodological approaches which reflect real-life settings, such as laboratory experiments or field experiments. Another weakness of online surveys is the subjects might use shortcuts and might be less attentive in online survey situations than in face-to-face interviews. Acknowledging these limitations, we conducted face-to-face interview as our preliminary step for its clarity and suitability based on the respondents' feedback.

There is a vast scope to enhance further studies of key behavioral economic principles when they are applied in energy conservation behavior. A growing number of literatures have called out for greater reliability on empirical research and its impact evaluation (i.e., generalizability and reliability), the durability of effects (short-term and long-term behavioral changes), and with larger scale interventions (Chan & Lau, 2002); (Pollitt & Shaorshadze, 2013). By understanding these irrational yet 'predictable' deviations from economic rationality, policymakers will be able to design behavioral interventions which effectively bridge the gap between their attitudes, intentions, and consumers' energy-related behaviors. This study provides empirical evidences of the values of applying insights from behavioral economics to inform effective policy designs and delivery methods of consumer-focused communication messages aimed at promoting household energy conservation.

In spite of valuable insights from the PSM analysis, this study confronts some limitations which require further research. Firstly, PSM only asks about price of a single product in isolation from other characteristics of the product and the analysis for a wider

energy-efficient product line. The future research should focus on investigating WTP the premium for wider energy-saving products, instead of taking only one product line. A number of previous literatures have incorporated consumers' WTP for several green products (Biswas & Roy, 2016); (Kucher, Hełdak, Kucher, & Raszka, 2019) and various ecological products (Canavari, Nocella, & Scarpa, 2003); (Leszczyńska, 2014). Extending the analysis for a wider range of green products would allow us to define optimal prices across a lager consumer profile. Secondly, PSM analysis is often criticized as a "direct" pricing technique where respondents are prone to underestimating their actual price perceptions. As such, future studies should combine PSM results with more quantitative analysis (e.g., regression analysis, conjoint analysis, etc.), which might help researchers or policymakers to increase the predictive quality of the price points in a wider range of circumstances.

REFERENCES

Aarts, H. D., A. (2000). Habits as knowledge structures: Automaticity in goal-directed behaviour. *Journal of Personality and Social Psychology, 69*, 53-63.

Abrahamse, W., & and Steg, L. (2009). How do socio-demographic and psychological factors relate to households' direct and indirect energy use and savings? *Journal of Economic Psychology, 30*, 711-720.

Abrahamse, W., Steg, L., & Charles, V. R., T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*(25), 273-291.

Agency, I. E. (2019). *Global Energy & CO2 Status Report*. Retrieved from Paris, France:

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211.

Ajzen, I. (2008). Consumer attitudes and behavior. *Handbook of Consumer Psychology*, 525-548.

Ali, S., Ullah, H., Akbar, M., & Akhtar, M. W. (2019). Determinants of Consumer Intentions to Purchase Energy-Saving Household Products in Pakistan. *Sustainability, 11*(1462).

Allcott, H., & Taubinsky, D. (2015). Evaluating Behaviorally Motivated Policy: Experimental Evidence from the Lightbulb Market. *AMERICAN ECONOMIC REVIEW, 105*(8), 2501-2538.

Antunes, D., Gaspar, R., & Lino, J. (2012). Energy efficient appliances and energy efficient behaviors: From consumer's assessment to behavior intervention. In *Energy Efficiency: Methods, Limitations and Challenges.* : Nova Science Publishers.

Ariely, D. (2008). Predictably irrational: the hidden forces that shape our decisions.

Armitage, C. J., & Conner, M. T. (2010). Efficacy of the Theory of Planned Behaviour: A Meta-Analytic Review. *British Journal of Social Psychology, 40*(4), 471 - 499.

Arttachariya, P. (2012). Environmentalism and green purchasing behavior: A study on graduate students in Bangkok, Thailand. *BU Acad. Rev, 11*, 1-11.

Baker, E. W., Hubona, G., & Al-Gahtani, S. S. (2007). The effects of gender and age on new technology implementation in a developing country: Testing the theory of planned behavior (TPB). *Information Technology & People, 20*(4), 352-375.

Bamberg, S. (2002). Effects of implementation intentions on the actual performance of new environmentally friendly behaviours – results of two field experiments. *Journal of Environmental Psychology, 22*, 399-411.

Birgelen, M., Semeijn, J. and Keicher, M. (2009). "Packaging and pro-environmental consumption behaviour: investigating purchase and disposal decisions for beverages". *Environmental Behaviour, 41*(1), 125-146.

Biswas, A., & Roy, M. (2016). A study of consumers' willingness to pay for green products. *Journal of Advanced Management Science, 4*(3).

Blackwell, R. D., Miniard, P.W., Engel, F.J. (2001). Consumer Behaviour. *Harcourt College Publishers*.

Borgstede, C. v., & Biel, A. (2002). Pro-Environmental Behaviour: Situational Barriers and Concern for the Good at Stake.

Brocklehurst, F. (2018). *Choosing energy efficiency – consumer response to operating costs at the point of sale.* Paper presented at the British Institute of Energy Economics conferencee, Consumers at the Heart of the Energy, Oxford.

Brown, M. (2003). Buying or browsing? An exploration of shopping orientations and online purchase intention. *European Journal of Marketing, 37*(11/12), 1666-1684.

Canavari, M., Nocella, G., & Scarpa, R. (2003). *Stated willingness to pay for environment-friendly production of apples and peaches: web-based versus in-person surveys.* Paper presented at the Paper presented at the 83rd EAAE Seminar.

Chan, R., & LBY, L. (2002). Explaining Green Purchasing Behavior: A Cross-Cultural Study on American and Chinese Consumers. *Journal of International Consumer Marketing, 14*, 9-40.

Chang, M. K. (1998). Predicting Unethical Behavior: A Comparison of the Theory of Reasoned Action and the Theory of Planned Behavior. *Journal of Business Ethics, 17*, 1825-1834.

Chaudhary, R., & Bisai, S. (2018). Factors influencing green purchase behavior of millennials in India. *Management of Environmental Quality, 29*(5), 798-812.

Cheng, S., Lam, T., & Hsu, C. H. C. (2005). Testing the sufficiency of the theory of planned behavior: A case of customer dissatisfaction responses in restaurants. *International Journal of Hospitality Management, 24*(4), 475-492.

Collins, S. E., & Carey, K. B. (2007). The theory of planned behavior as a model of heavy episodic drinking among college students. *Psychol. Addict, 21*, 498-507.

Connelly. (2008). Pilot Studies. *Medsurg Nursing, 17*(6), 411-412.

EGAT. (2016). *EGAT Annual Report*. Retrieved from

EGAT. (2019). *EGAT Annual Report*. Retrieved from

Fazio, R. H. (1995). Attitudes as object-evaluation associations: Determinants, consequences, and correlates of attitude accessibility. *Attitude Strength Anteced. Conseq., 4*, 247-282.

Fielding, K. S., McDonald, R., & Louis, W. R. (2008). Theory of planned behaviour, identity and intentions to engage in environmental activism. *J. Environ. Psychology, 28*, 318-326.

Frederiks, E. R., , K. S., & Hobman, E. V. (2015). Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour. *Renewable and Sustainable Energy Reviews, 41*, 1385–1394.

Frederiks, E. R., Stenner, K., & Hobman, E. V. (2015). The Socio-Demographic and Psychological Predictors of Residential Energy Consumption: A Comprehensive Review. *Energies*, 573-609.

Gabor, A., & Granger, C. W. J. (1966). Price as an Indicator of Quality: Report on an Enquiry. *Economica*, *33*(129), 43-70.

Gabrielcik, A., & Fazio, R. H. (1984). Priming and frequency estimation: A strict test of the availability heuristic. *Personality and Social Psychology Bulletin, 10*, 85-89.

Gamma, K., Reeck, C., & Weber, E. U. (2015). Decision modes' influence on energy choices in the USA and Switzerland.

Gill, C., Atlas, S., & Hardisty, a. D. (2016). Matching costs to context: Status quo bias, temporal framing, and household energy decisions

Hair, J. F., Black, W. C., Babin, B. J. & Anderson, R. E. (2010). Multivariate Data Analysis (7th ed.). *Prentice Hall*.

Han, H., Hsu, L.-T. J., & Sheu, C. (2011). Application of the Theory of Planned Behavior to Green Hotel Choice: Testing the Effect of Environmental Friendly Activities. *Application of the Theory of Planned Behavior to Green Hotel Choice: Testing the Effect of Environmental Friendly Activities*, *30*(3), 325-334.

Hardisty, D. J., Appelt, K. C., & Weber, E. U. (2009). I want it now! Why discount rates for losses show reverse frame and reverse magnitude effects.

Hardisty, D. J., Shim, Y., Sun, D., & Griffin, D. (2017). Encouraging Energy Efficiency: Product Labels Facilitate Temporal Tradeoffs. *Society for Consumer Research*.

Howell, S. E., & Laska, L. B. (1992). The changing face of the environmental coalition: a research note. *Environment and Behavior, 24*, 134-144.

Hua, L., & Wang, S. (2019). Antecedents of Consumers' Intention to Purchase Energy-Efficient Appliances: An Empirical Study Based on the Technology Acceptance Model and Theory of Planned Behavior. *Sustainability, 11*(2994).

Huddart-Kennedy, E., Beckley, T. M., McFarlane, B., & Nadeau, S. (2009). Why we don't "walk the talk": understanding the environmental values–behaviour gap in Canada. *Human Ecology Review, 16*(2), 151–160.

Iyengar, S. S., & Lepper, M. R. (2000). When choice is demotivating: Can one desire too much of a good thing? *Journal of Personality and Social Psychology, 79*(6), 995-1006.

Jöreskog, K. G. S., D. (1996). Lisrel 8: Structural equation modeling with the SIMPLIS command language. *Scientific Software International*.

Joshi, P. D., & Fast, N. J. (2013). Power and Reduced Temporal Discounting. *Psychological Science*.

Kahneman, D. (2003). Maps of Bounded Rationality: Psychology for Behavioral Economics. *AMERICAN ECONOMIC REVIEW, 93*, 1449-1475.

Kahneman, D., & Tversky, A. (2000). Choices, Values, and Frames. *Cambridge University Press*.

Kline, R. B. (2011). Methodology in the Social Sciences. *Principles and practice of structural equation modeling (3rd ed.)*.

Kollmuss, & Agyeman. (2002). Mind the Gap: why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research, 8*(3), 239-260.

Kucher, A., Hełdak, M., Kucher, L., & Raszka, B. (2019). Factors Forming the Consumers' Willingness to Pay a Price Premium for Ecological Goods in Ukraine. *International Journal of Environmental Research and Public Health, 16*(5).

Kupiec, B., & Revell, B. (2001). Measuring consumer quality judgments. *British Food Journal, 103*, 7-22.

Kyrgyzstan, U. (Producer). (2019, November 6). kg.undp.org. Retrieved from https://www.kg.undp.org/content/kyrgyzstan/en/home/presscenter/articles/2019/11/undp-is-promoting-energoeffciency-in-kyrgyzstan--results-of-the-.html

Leelakulthanit, O. (2014). The Factors Affecting The Adoption Of LED Lamps. *International Business & Economics Research Journal, 13*(4), 757-768.

Leszczyńska, A. (2014). Willingness to Pay for Green Products vs Ecological Value System. *International Journal of Synergy and Research, 3*, 67-77.

Linden, A.-L., Carlsson-Kanyama, A., & Eriksson, B. (2006). Efficient and inefficient aspects of residential energy behaviour: what are the policy instruments for change? *Energy Policy, 34*, 1918-1927.

Maichum, K., Parichatnon, S., & Peng, a. K.-C. (2017). Factors Affecting on Purchase Intention towards Green Products: A Case Study of Young Consumers in Thailand. *International Journal of Social Science and Humanity, 7*(5), 330-335.

Mannetti, L., Pierro, A., & Livi, S. (2004). Recycling: Planned and self-expressive behaviour. *Journal of Environmental Psychology, 24*, 227-236.

McCalley, L. T. (2006). From motivation and cognition theories to everyday applications and back again: the case of product-integrated information and feedback. *Energy Policy, 34*(2), 129-137.

Ministerial, C. E. (2018). *Global Lighting Challenge Fact Sheet*. Retrieved from Paris, France:

Molina-Moreno, V., Leyva-Díaz, J. C., Sánchez, J., & Peña-García, A. (2017). Proposal to Foster Sustainability through Circular Economy-Based Engineering: A Profitable Chain from Waste Management to Tunnel Lighting. *Sustainability, 9*(2229).

Moser, A. K. (2015). Thinking green, buying green? Drivers of pro-environmental purchasing behavior. *Journal of Consumer Marketing, 32*, 167-175.

Mostafa, M. M. (2007). A hierarchal analysis of the green consciousness of the Egyptian consumer. *Psychology and Marketing, 24*, 445-473.

Nguyen, T. P. L., & Peña-García, A. (2019). Users' Awareness, Attitudes, and Perceptions of Health Risks Associated with Excessive Lighting in Night Markets: Policy Implications for Sustainable Development. *Sustainability, 11*(21).

Northcraft, G. B., & ANeale, M. (1986). Opportunity costs and the framing of resource allocation decisions. *Organizational Behavior and Human Decision Processes, 37*(3), 348-356.

Núñez-Cacho, P. (2018). The Use of Led Technology and Biomass to Power Public Lighting in a Local Context: The Case of Baeza (Spain). *Sustainability, 11*(1783).

Nuttavuthisit, K., & Thøgersen, J. (2015). The importance of consumer trust for the emergence of a market for green. *J. Bus. Ethics*.

Patanadul, P. (2015). FACTORS AFFECTING PURCHASE INTENTION OF ECO-PRODUCTS AMONG CONSUMERS IN PAK KRET AREA, NONTHABURI PROVINCE. *Silpakorn University*.

Pollitt, M. G., & Shaorshadze, I. (2013). The role of behavioural economics in energy and climate policy. *Handbook on Energy and Climate Change*.

Programme, U. N. E., Facility, G. E., & (U4E), U. f. E. (2017). *Accelerating the global adoption of energy-efficient lighting*. Retrieved from Paris, France:

Prothero, A., Dobscha, S., Freund, J., Kilbourne, W. E., Luchs, M. G., Ozanne, L. K., & Thøgersen, J. (2011). Consumption: Opportunities for Consumer Research and Public Policy. *Journal of Public Policy & Marketing, 30*(1), 31–38.

Prothero, A., & Fitchett, J. A. (2000). Greening Capitalism: Opportunities for a Green Commodity. *Journal of Macromarketing, 20*(1), 46–55.

Ramayah, T., Lee, J. W. C., & Mohamad, O. (2010). . Green product purchase intention: some insights from a developing country. *Journal of Resources, Conservation and Recycling, 54*, 1419-1427.

Reynolds, T., Kolodinsky, J., & Murray, B. (2012). Consumer preferences and willingness to pay for compact fluorescent lighting: Policy implications for energy efficiency promotion in Saint Lucia. *Energy Policy, 41*(C), 712-722.

Ritter, Á. M., Borchardt, M., Vaccaro, G. L., Pereira, G. M., & Almeida, F. (2015). Motivations for promoting the consumption of green products in an emerging country: Exploring attitudes of brazilian consumers. *Journal of Cleaner Production, 106*, 507-520.

Roll, O., Achterberg, L. H., & Herbert, K. G. (2010). *Innovative Approaches to Analyzing the Price Sensitivity Meter. Results of an international comparative study.* Paper presented at the COMBI2010 Conference Proceedings.

Saichao, L. (2016). A STUDY ON FACTORS AFFECTING CUSTOMER'S ATTITUDE TOWARD INTENTION TO PURCAHSE GREEN PRODUCTS IN BANGKOK, THAILAND. *Bangkok University*.

Schultz, P. W. (2014). Strategies for promoting proenvironmental behavior: Lots of tools but few instructions. *European Psychologist, 19*(2), 107-117.

Seaver, W. B., & Patterson, A. H. (1976). DECREASING FUEL-OIL CONSUMPTION THROUGH FEEDBACK AND SOCIAL COMMENDATION. *Journal of Applied Behavior Analysis, 9*(2).

Sheppard, B. H., Hartwick, J. & Warshaw, P. R. (1988). The theory of reasoned action: A meta-analysis of past research with recommendations for modifications and future research. *Journal of Consumer Research, 15*, 325-343.

Shogren, J. F. (2012). Behavioural Economics and Environmental Incentives. *OECD Publishing*.

Stern, P. (1992). What psychology knows about energy conservation. *The American Psychologist, 47*, 1224–1232.

Stern, P. C., & Gardner, G. T. (1981). Psychological research and energy policy. *American Psychologist, 36*(4).

Sustainability, J. f. (Producer). (2017, September 4). Japanfs.org. Retrieved from https://www.japanfs.org/en/news/archives/news_id035897.html

Sutton, P. (2004). A perspective on environmental sustainability: In Paper on the Victorian Commissioner for Environmental Sustainability. *RSTI Publications, Inc*, 1-32.

Tan, C.-S., Ooi, H.-Y., & Goh, Y.-N. (2017). A moral extension of the theory of planned behavior to predict consumers' purchase intention for energy-efficient household appliances in Malaysia. *Energy Policy, 107*(C), 459-471.

Tangari, A. H., & Smith, R. J. (2012). How the Temporal Framing of Energy Savings Influences Consumer Product Evaluations and Choice. *Psychology & Marketing, 29*(4), 198-208.

Tanner, C. a. K., S.W. (2003). Promoting Sustainable Consumption Determinants of Green Purchases by Swiss Consumers. *Psychology and Marketing, 20*, 883-902.

Taylor. (1982). The availability bias in social perception and interaction. 190–200.

Taylor, P. G., d'Ortigue, Lavagne, O., Francoeur, M., & Trudeau, N. (2010). Final energy use in IEA countries: The role of energy efficiency. *Energy Policy, 11*, 6463-6474.

Taylor, S., & Todd, P. (1995). Decomposition and crossover effects in the theory of planned behavior: A study of consumer adoption intentions. *Int. J. Res. Mark, 12*, 137-155.

Thaler, R. (1981). Some empirical evidence on dynamic inconsistency. *Economics Letters, 8*(3), 201-207.

Thaler, R. H., & Sunstein, C. R. (2008). Nudge: Improving Decisions about Health, Wealth, and Happiness. *Yale University Press*.

Thøgersen, J., & Ölander, F. (2003). Spillover of environment-friendly consumer behavior. *Journal of Environmental Psychology, 23*(3), 225-236.

Torgler, B., García-Valiñas, M. A., & Macintyre, A. (2008). Differences in preferences towards the environment: the Impact of a gender, age and parental effect. *Fondazione Eni Enrico Mattei, 18*.

Tsarenko, Y., Ferraro, C., Sands, S., & McLeod, C. (2013). Environmentally conscious consumption: The role of retailers and peers as external influences. *Journal of Retailing and Consumer Services, 20*(3), 302-310.

Tversky, Amos, & Kahneman, D. (1974). Judgment Under Uncertainty: Heuristics and Biases. *Science, 185*(4157), 1124-1131.

Van Westerndorp, P. (1976). *NSS-Price Sensitivity Meter (PSM)- A new approach to study consumer perception of price.* Paper presented at the Proceedings of the ESOMAR Congress.

Vermeir, I., & Verbeke, r. (2006). Sustainable Food Consumption: Exploring the Consumer "Attitude – Behavioral Intention" Gap. *Journal of Agricultural and Environmental Ethics, 19*(2), 169–194.

Verplanken, B., & Wood, W. (2006). Interventions to break and create consumer habits. *Journal of Public Policy & Marketing, 25*, 90–103.

Vongmahadlek, J. (2012). An empirical study on organic product purchasing behavior: A case study of thailand. *AU J. Manag, 10*, 31–39.

Wiriyapinit, M. (2007). Is thai culture the right culture for knowledge management?: An exploratory case study research. *Chulalongkorn Rev, 74*, 80-90.

Yadav, R., & Pathak, G. S. (2017). Determinants of Consumers' Green Purchase Behavior in a Developing Nation: Applying and Extending the Theory of Planned Behavior. *Ecological Economics, 134*(C), 114-122.

VITA

NAME	Nuttakrij Apipuchayakul
DATE OF BIRTH	17 September 1990
PLACE OF BIRTH	Bangkok, Thailand
INSTITUTIONS ATTENDED	High School: Trinity International School Bachelor Degree: Chulalongkorn University (BA in Economics) Master Degree: School of Oriental and African Studies, University of London, UK (MSc in Global Energy and Climate Policy) Doctor of Philosophy: Chulalongkorn University (Environment, Development, and Sustainability Program)
HOME ADDRESS	311 Panichayakarnthonburi Wat Tha Phra, Bangkokyai Bangkok, Thailand 10600
PUBLICATION	Apipuchayakul, N.; Vassanadumrongdee, S. Factors Affecting the Consumption of Energy-Efficient Lighting Products: Exploring Purchase Behaviors of Thai Consumers. Sustainability 2020, 12, 4887.