A Study of Sustainability in the Energy Sector in Myanmar Between 2011 And 2020

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การศึกษาความยั่งยืนในภาคพลังงานในประเทศเมียนมาระหว่างปี 2011 และ 2020

น.ส.คลารา มัง ซุย ทัง

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรมหาบัณฑิต
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บทคัดย่อ

ในสังคมสมัยใหม่ พลังงานกลายมาเป็นกลไกที่จำเป็นต่อการยังชีพ ซึ่งไม่เพียงแต่เกี่ยวโยงกับเสาหลักด้านสิ่งแวดล้อมของการพัฒนาที่ยั่งยืนเท่านั้น แต่ยังเกี่ยวโยงอย่างแยกไม่ออกกับเสาหลักด้านเศรษฐกิจและสังคมอีกด้วย งานวิจัยนี้ใช้ประโยชน์จากวิธีวิจัยเชิงคุณภาพและทำการศึกษาเชิงวิพากษ์ซึ่งระดับของความยั่งยืนในภาคพลังงานของประเทศเมียนมาระหว่างปี 2011 และ 2020 โดยใช้ปี 2011 เป็นฐาน และพิจารณาสามปัจจัยสำคัญหลัก ได้แก่ ความมั่นคงทางพลังงาน การคำนึงถึงสิ่งแวดล้อมในการผลิตพลังงาน และความมั่นคงทางการเงินในภาคส่วนนั้นๆ

ความมั่นคงทางพลังงานซึ่งหมายถึงการมีแหล่งพลังงานที่สามารถใช้ได้โดยไม่ถูกขัดขวางในราคาที่เหมาะสม ได้ถูกศึกษาจากข้อมูลชั้นรองแบบมหภาคร่วมกับการวิเคราะห์นโยบายพลังงานต่างๆ ที่มีอยู่ ผลการศึกษาได้ข้อสรุปว่าถึงแม้รัฐบาลผสมของเมียนมาสองรัฐบาลที่ผ่านมาจะสามารถสร้างและนำเข้าพลังงานเพื่อตอบสนองความต้องการที่เพิ่มสูงขึ้นและสามารถคงความมั่นคงทางหลังงานเอาไว้ได้ แต่รัฐบาลดังกล่าวก็ยังมิได้พัฒนาความมั่นคงทางพลังงานระหว่างช่วงเวลาที่ศึกษาเท่าที่ควร

สาขาวิชา	การพัฒนาระหว่างประเทศ	ลายมือชื่อนิสิต ....
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In modern society, energy becomes a life supporting mechanism, as it is not only entangled with the environment pillar of sustainable development, but also inseparably related to the economic and social pillars of society. Taking advantage of a qualitative research method, this study critically examines the level of sustainability of Myanmar's energy sector between 2011 and 2020, using 2011 as a baseline, by observing three critical components: energy security, environmental considerations in energy production and securing financial health for the sector.

Energy security, possessing uninterrupted availability of energy sources at an affordable price, is studied from available macro secondary data in conjunction with an analysis of existing energy policies. The study concludes that, although the two successive Myanmar's Union governments were able to generate and import energy to meet its soaring demand and maintain its energy security, it still fell short to improve energy security during the studied period.

This thesis finds that environmental policy integration in the energy sector at the Union level is the most vibrant

Field of Study:	International Development Studies	Student's Signature ....
Academic Year:	2021	Advisor's Signature ....

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For my father, with love

A STUDY OF SUSTAINABILITY IN THE ENERGY SECTOR IN MYANMAR BETWEEN 2011 AND 2020

Abstract

In modern society, energy becomes a life supporting mechanism, as it is not only entangled with the environment pillar of sustainable development, but also inseparably related to the economic and social pillars of society. Taking advantage of a qualitative research method, this study critically examines the level of sustainability of Myanmar's energy sector between 2011 and 2020, using 2011 as a baseline, by observing three critical components: energy security, environmental considerations in energy production and securing financial health for the sector.

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This thesis finds that environmental policy integration in the energy sector at the Union level is the most vibrant among the three components. Although there is still a long journey to undertake to meet international standards, the country was able to graduate from "traditional" environmental management and transitioned into a sound streamlined environmental safeguarding mechanism in the sector.

Furthermore, the examination of Myanmar's energy sector financial health in this study reflects the vital role energy tariffs play in the sustainability of a market economy. Although the two successive governments were able to raise electricity tariffs twice during the studied period, which new tariffs resulted in some improvement in the energy sector's financial health, the sector still needs massive subsidies from the Union's budget. This insecure financial health has impacted the sector's productivity and functionality, but it also has a negative effect on the country's wider socio-economic development, specifically affecting those who do not have access to modern electricity.

Although this study does not find current satisfactory trends in any of the three studied components, it notes the improvements that the country was able to make especially considering the starting point of the journey - newly transitioning into a semi-democratic society from a military dictatorship. The study also provides pragmatic recommendations for the sector's sustainability based on its research. By observing the energy sector from a bird's eye view, this paper intends to initiate a deeper understanding of sustainability in Myanmar's energy sector and potentially offer new premises and contentions for further debate on the subject.

Keywords: Energy security, Energy policy, Environmental policy, Energy Tariffs, Myanmar

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บทคัดย่อ

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ความมั่นคงทางพลังงานซึ่งหมายถึงการมีแหล่งพลังงานที่สามารถใช้ได้โดยไม่ถูกขัดขวางในราคาที่เหมาะสม ได้ถูกศึกษาจากข้อมูลชั้นรองแบบมหภาคร่วมกับการวิเคราะห์นโยบายพลังงานต่างๆ ที่มีอยู่ ผลการศึกษาได้ข้อสรุปว่าถึงแม้รัฐบาลผสมของเมียนมาสองรัฐบาลที่ผ่านมาจะสามารถสร้าง และนำเข้าพลังงานเพื่อตอบสนองความต้องการที่เพิ่มสูงขึ้นและสามารถคงความมั่นคงทางหลังงานเอาไว้ได้ แต่รัฐบาลดังกล่าวก็ยังมิได้พัฒนาความมั่นคงทางพลังงานระหว่างช่วงเวลาที่ศึกษาเท่าที่ควร

วิทยานิพนธ์ฉบับนี้พบว่าการบูรณาการนโยบายสิ่งแวดล้อมในระดับสหภาพมีการเคลื่อนไหวมากที่สุดจากสามองค์ประกอบ ถึงแม้ว่าจะยังคงห่างไกลจากมาตรฐานนานาชาติ แต่ประเทศเมียนมาก็สามารถหลุดพ้นจากการบริหารจัดการพลังงานในรูปแบบดั้งเดิมและเปลี่ยนผ่านไปสู่กลไกการปกป้องสิ่งแวดล้อมที่คล่องตัวและมีความสมเหตุสมผลในภาคส่วนนั้นๆ ได้

นอกจากนี้ การตรวจสอบสุขภาวะทางเศรษฐกิจในภาคส่วนพลังงานของประเทศเมียนมาในงานศึกษานี้ยังสะท้อนบทบาทสำคัญของภาษีพลังงานต่อความยั่งยืนทางเศรษฐกิจแบบตลาด ถึงแม้ว่ารัฐบาลสองรัฐบาลที่ผ่านมาสามารถที่จะเพิ่มอัตราภาษีไฟฟ้าสองครั้งระหว่างช่วงเวลาที่ศึกษา ซึ่งภาษีใหม่นี้ส่งผลให้เกิดการพัฒนาในสุขภาวะทางเศรษฐกิจภาคส่วนพลังงานบ้าง แต่ภาคส่วนนี้ยังคงต้องการการอุดหนุนจำนวนมหาศาลจากงบประมาณของรัฐบาลกลางอยู่ สุขภาวะทางเศรษฐกิจที่ไม่มั่นคงนี้ส่งผลกระทบต่อผลิตภาพและการดำเนินงานของภาคส่วน และยังมีผลทางลบต่อการพัฒนาทางสังคมและเศรษฐกิจของประเทศในวงกว้างมากขึ้น โดยเฉพาะกระทบต่อกลุ่มคนที่ไม่สามารถเข้าถึงไฟฟ้าแบบสมัยใหม่ได้

แม้ว่างานศึกษานี้จะไม่พบแนวโน้มปัจจุบันที่น่าพึงพอใจในองค์ประกอบทั้งสามส่วน แต่ก็แสดงให้เห็นถึงการพัฒนาที่ประเทศเมียนมาสามารถทำได้ โดยเฉพาะเมื่อพิจารณาถึงจุดเริ่มต้น คือระยะต้นของการเปลี่ยนผ่านไปสู่สังคมกึ่งประชาธิปไตยจากระบอบเผด็จการทหาร งานศึกษานี้ยังให้คำแนะนำเชิงปฏิบัติสำหรับความยั่งยืนของภาคส่วนที่มีพื้นฐานอยู่บนงานศึกษานี้ด้วย โดยสังเกตภาคส่วนพลังงานจากภาพมุมสูง งานศึกษานี้มีจุดประสงค์เพื่อริเริ่มความเข้าใจที่ลึกซึ้งมากขึ้นเกี่ยวกับ

ความยั่งยืนในภาคพลังงานของประเทศเมียนมาและความเป็นไปได้ที่จะนำเสนอพื้นที่ใหม่ๆ และการถกเถียงต่อไปสำหรับหัวข้อดังกล่าว

คำสำคัญ: ความมั่นคงทางพลังงาน, นโยบายพลังงาน, นโยบายสิ่งแวดล้อม, ค่าพลังงาน, ประเทศเมียนมา

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Lists of Abbreviations

ADB	Asian Development Bank
AEC	ASEAN Economic Community
ASEAN	Association of Southeast Asian Nations
Bcf	Billion cubic feet
BOPD	Barrel of oil per stream day
CNG	Compressed natural gas
DRD	Department of Rural Development
EIAs	Environmental impact assessments
ERIA	Economic Research Institute for ASEAN and East Asia
EU	European Union
FDI	Foreign Direct Investment
FY	Fiscal year
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GMSSF	Greater Mekong Subregion Strategic Framework
GWh	Gigawatt-hour
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
INDC	Intended National Determined Contribution
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
Ktoe	Kiloton of oil equivalent
KW	Kilowatt
kWh	Kilowatt hour
LCOE	Levelized cost of energy
LPG	Liquefied petroleum gas
MCCS	Myanmar Climate Change Strategy
Mcf	Million cubic feet
MOALI	Ministry of Agriculture, Livestock and Irrigation
MoE	Ministry of Energy
MOE	Ministry of Education
MOECAF	The Ministry of Environmental Conservation and Forestry
MOEE	Ministry of Electricity and Energy
MOEP	Ministry of Electric Power
MOGE	Myanmar Oil and Gas Enterprise
MSDP	Myanmar Sustainable Development
Mtoe	Million tons of oil equivalent
MW	Megawatt
NEP	National Electrification Plan
NLD	National League for Democracy
OBG	Oxford Business Group
OECD	Organization for Economic Cooperation and Development
PPAs	Power Purchase Agreements
REN21	Renewable Energy Policy Network for the 21^{st} Century
RES	Renewable energy sources

SDG/SDGs	Sustainable Development Goal/s
SLOR	State Law and Order Restoration Council
SMEs	Small and Medium Sized Enterprises
Tcf	Trillion cubic feet
TFEC	Total Final Energy Consumption
Toe	Tons of oil equivalent
TPEP	Total Primary Energy Production
TPES	Total Primary Energy Supply
UN	United Nations
W	Watt
WCED	World Commission on Environment and Development

CHAPTER ONE
INTRODUCTION

1.1 Background

Sustainability has become a catchy word nowadays. Although it was brought up to the UN's platform regarding the notion of saving the environment, it is now embedded into many aspects of our society. A few examples include sustainable fashion, sustainable consumption and production, sustainable growth, sustainable citizenship, etc. (Micheletti et. al 2012). One of the most influential and well-known sustainability projects today is the UN's Sustainable Development Goals which involves governments across the world. Yet, what is sustainability as an academic concept? What does sustainability in the energy sector mean?

Myanmar has been participating in the discourse of the UN's development agendas since the previous military regime. Without financial and technical assistance, or the encouragement of the UN and of the international community, self-imposing these ambitious goals, such as the Sustainable Development Goals, would have been challenging for an under-developed country like Myanmar. After the finalization of the Millennium Development Goals and the development of Sustainable Development Goals (SDGs) in 2015, Myanmar adopted and translated several development agendas, including the SDGs, into its local versions. Therefore, it is not surprising to observe that for any successive governments in Myanmar, sustainability arguably means the UN's notion of sustainable development. In today's Myanmar, addressing sustainability only exists within the limit and boundary of the present Sustainable Development Goals.

Energy is the life support system that underpins the entire mechanism of a modern society as production and consumption activities involve direct or indirect energy consumption (Asghar 2008. P167; Mahalik et. al 2014). Energy is relational to many of the social, economic and environment matters of a country. Energy insufficiency does not merely affect an industrialized economy but also many aspects of human social progress and development. For instance, lack of energy does not merely mean not being able to turn on lights or use household electric appliances. It also leads to its impact on the education of children and teachers, the healthcare system and health workers, the living standard of society, and so forth. Therefore, energy poverty is one of the barriers to a country's social and economic development (Turkoglu et. al 2018; Asghar 2008).

The generation of energy has also been one of the major natural resource manipulators regardless of the means of production and the used energy sources (Robbins et. al 2014). Robbins and colleagues (2014) argue that any consumption, including green consumption, is still consumption. In other words, it is impossible to generate and/or consume energy without manipulating natural resources. At best, we can only minimize the impact on the environment. Therefore, energy is one of the sectors that governments always need to trade-off with the environment. The challenge for policy makers is how much we are willing to satisfy the country's energy demand at the expense of our environment and natural resources, which will then impact society as a whole.

2011 was a crucial year for Myanmar. After being ruled by successive military dictatorships since the 1962 coup, a semi-civilian led government, chaired by President Thein Sein, took office in the same year and initiated several critical reforms in various social and economic sectors, including a major reform in the energy sector. For example, the Union government responded to the public outcry for "green" and "ethical" generation of energy by postponing the massive Myitsone dam project co-sponsored by a China state-owned company (Turnell 2012), and initiated critical legal and policy reforms in the energy sector (Duane Morris & Selvam LLP 2020; Than 2014). Several key plans and roadmaps for the energy sector were also established by Thein Sein's government. When the NLD government came into office in 2016, after a landslide victory in the general election of 2015, all these strategies and plans were adopted including the strategic plan to achieve universal electrification by 2030.

Even though Myanmar has been blessed with massive energy potential, today it still stands out as the country with significant energy poverty in the ASEAN region: only 54% of its population has access to electricity as an example. Successive Myanmar governments have set a vision and a strategic plan to accelerate the generation of energy and meet 100% electrification by 2030. Setting aside whether this plan has a high probability of success or not, there is a big question whether sustainability is properly and accurately addressed in its energy sector. By arguing for the implementation of the UN Sustainable Development Goals, this paper attempts to propose that, currently, Myanmar does not sufficiently address sustainability in the energy sector. For instance, SDG 7 (the energy goal of SDGs) does not provide sufficient environmental protection in either energy generation, transmission, distribution, nor consumption. To protect the environment and the bigger aspect of the ecology, one has to do so under different goals such as SDG 13 (climate action), SDG 14 (life below water), SDG 15 (life on land) etc. This paper, therefore, points out that insufficiently addressing the environment in the energy sector itself, as outlined in SDG 7, rather contradicts the notion of sustainability. Although sustainability was inserted in the UN's platform to raise awareness of protection of the environment, the concept is rather nuanced and defined by countless scholars. Studying sustainability in the energy sector, as IAEA et. al 2005 points out, is rather similar to a medical check-up. It has to be an individual approach i.e., one set of health data could not be used to evaluate the health of the general public. Each and every individual has to be evaluated based on their unique height, body mass, etc. This study, thus, develops a unique triad conceptual framework in order to investigate sustainability in the energy sector, going beyond the boundary of SGD 7. Even though the country currently has an uncertain future, due in part to the escalating political unrest, understanding the sustainability of the energy sector between 2011 and 2020 will help set a tone for future energy policy formulation and implementation.

1.2 Research Questions

Main Question: What is the level of sustainability accomplished in Myanmar's energy sector between 2011 to 2020?

a) What was the level of energy security in Myanmar between 2011 and 2020?
b) How much consideration of the effect on the environment, and the transition into renewable energy sources, was given by the Myanmar Union government's energy policy during this period?
c) What was the energy sector's financial health during this period?

1.3 Research Objectives

In a modern society, energy has a fundamental relationship to all the three pillars of sustainable development. Acknowledging this important role, this paper investigates the level of sustainability in the energy sector of Myanmar by means of examining current academic research and other data in identifying three key components – energy security, progressive environmental considerations and the energy sector's financial health between 2011 and 2020.

Energy security is defined as the uninterrupted availability of energy sources at an affordable price. This paper primarily investigates the Myanmar energy sector's supply chain macro-data: the total primary energy supply (TPES) and the total final energy consumption (TFEC), as well as the then existing energy policies through the end of 2020. The study of the macro-data is intended to portray the on-the-ground energy reality which is crucial to understanding the energy production, supply and consumption, and, further, helps the examination of the current energy policy which supplements the national strategy targeting energy security.

Environmental considerations are also studied at the national policy level. Although some Myanmar states and regions have developed respective environmental laws, this study investigates the Union government's environmental safeguarding policies, particularly in electricity generation, transmission and distribution by examining the environment protection mechanism integration in the Union-level policy. This targeted analysis amplifies the much-needed progressive consideration of the environment in the energy sector.

In examining the energy sector's financial health, this paper presents two competing arguments on this subject - the "equity perspective" (i.e. the moral responsibility of the Union government to provide its citizens with the basic public common goods) versus the "business model perspective" (i.e. balancing the sector's expenses which need to be covered by its revenue in order to achieve a sustainable operation). This paper carefully evaluates the existing energy tariff structures, considering the arguments of both sides, and proposes a sound tariff structure in order to make the sector self-sustaining.

This study's objectives, however, are by no means to predict the condition of the energy sector after the February 2021 coup, nor to compare the success or failure, if any, of the two successive Union governments. It is rather to observe and reflect on the journey towards the achievement of sustainability in Myanmar's energy sector between 2011 and 2020, and potentially, initiate further debates on the topic.

1.4 Significance of Research

Very few studies have been conducted on the sustainability of Myanmar's energy sector. The existing studies primarily and separately cover renewable energy, energy security through environmental protection, or the necessary electrification of the country. While these important studies are highly useful and contribute immensely on the academic discourse, they fail to thoroughly address the sustainability of the entire energy sector. As this study argues, addressing renewable energy in isolation as a subset of the sector does not help achieve sustainability of the sector. This study articulates as one of its major arguments that sustainability requires a unique adaptation in each country, specifically, that all nations cannot implement at unison set of ideal sustainability measurements as their respective development stage varies.

This study, therefore, attempts to develop a unique, tailored-made sustainability framework for Myanmar's energy sector going beyond renewable energy sources, by targeting energy security, examining progressive environmental considerations and measures to strengthen the financial health of the sector. The underlying logic for this is that energy security is paramount to sustainability. Without having sufficiently available and affordable energy first and foremost, how can the government address the sustainability of energy? Subsequently, one cannot omit the environmental pillar when addressing sustainability, in that the environment is not a subset or a by-product of society, unlike the economy (Adams 2006). Lastly, sustainability in a market economy comes at a price. Thus, financial health considerations need also to be examined. Through this unique conceptualization of sustainability in the energy sector, as well as critical and philosophical analysis of the macro-data and other relevant research, this paper attempts to produce a deeper understanding of the sector and its sustainability, and subsequently, ignite further debate on this rather crucial topic. This paper also offers, based on the research it conducted, pragmatic recommendations for policy changes which will strengthen sustainability in the energy sector of the country.

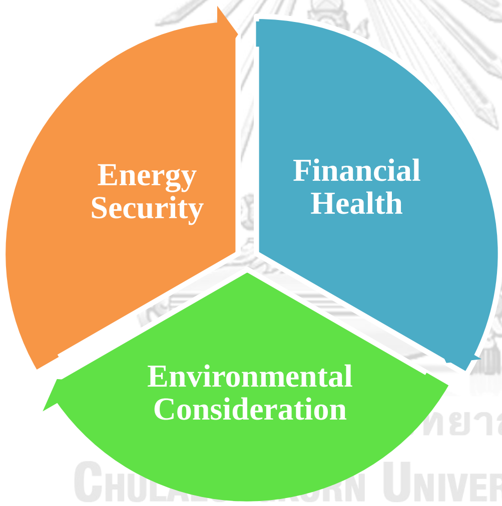
1.5 Conceptual Framework - Sustainability

Sustainability, without a doubt, has become a highly desirable term for governments, policy makers, stakeholders, environmentalists, economists, scholars, and practically anyone in society. Even though the concept emerged based on a growing awareness of climate change (Adams 2006; Baker et. al 2008; Munasinghe 1993 & 2007; Jacobus 2006; Hysing 2010), sustainability is now applied in many other aspects of society, such as sustainable growth, sustainable production and consumption, sustainable fashion, sustainable citizenship (widely discussed by Micheletti et. al 2012), and so on. Scholars define and measure sustainability in various ways ranging across a wide spectrum – from purely environmental protection to responsible capitalist ideology, as well as addressing the whole life support system. While there are suggestions to add additional pillars to sustainability such as governance and technology, most scholars agree to stick with the famous three pillars: the environment, social and the economy. The complex concept of sustainability, and how it is addressed by several renowned scholars, is further discussed in the literature review. The literature review further addresses the concept that energy sustainability is not just a sectoral issue, because energy, even if by some miracle would not have an impact on the environment, it would still be a major concern for the economic and social pillars.

What is sustainability in the energy sector then? In other words, what are we talking about when we discuss sustainability in the energy sector? Addressing sustainability in the energy sector is very similar to a patient's medical checkup (an example used in IAEA et. al 2005). By checking a patient's health data over time (body temperature, weight, blood pressure etc.), doctors can evaluate the subject's health. As individuals are unique (e.g. some naturally have higher blood pressure), a set of ideal health data/criteria cannot be used universally. The same concept of "uniqueness" applies to sustainable development of a country. As nations are at different development stages, sustainability cannot be addressed uniformly across the globe in order to achieve desirable results in each country. As one cannot have an absolute perfect health, an individual nation cannot achieve perfect sustainability in its energy sector as well as in its broader development agenda. In other words, sustainability is not about being perfect: it is about continuously getting better, as its process has an open-ended nature. Moreover, although renewable energy sources are highly desirable, they do not unfortunately guarantee sustainability especially when addressing the whole energy sector of a country.

Therefore, for Myanmar's energy sector sustainability, this paper identifies three major components – energy security, progressive consideration of the environment in the energy sector, and, last but not least, the sector's financial health based on the nature of country's energy sector. A sustainable energy sector would have an improving trend in all three areas – having energy security for domestic consumption, progressive realization of the importance of the environment in the sector and strengthening the financial health of the sector.

Figure 1. Conceptual Framework – Sustainability in the Energy Sector



1.5.1 Energy Security

Energy security, defined as possessing and supplying sufficient energy meeting the demand in the country (what Yao and Chang (2014) call "conventional energy security"), is fundamental for sustainable development in the energy sector (Davidsdottir 2012). Addressing energy security first and foremost when aiming for sustainability is rather obvious. In a sense, a nation must possess an object before it can talk about sustaining it. How can a government address sustainability of an object that it does not have? In a simpler term, before a woman decides what hair color and hair style she wants, she needs to have some hair first. Therefore, this paper addresses conventional energy security: having sufficient energy meeting the domestic demand as one main pillar of its conceptual framework.

As opined by Kurian (2012), energy insufficiency is an obstacle to sustainable development. Echoing this idea, providing consistent, reliable and affordable energy to all is also intensely addressed by SDG 7: "ensure access to affordable, reliable, sustainable and modern energy for all" through its five targets and six indicators (UN SDG). This provision of energy should not only be for individual households, but also for industry, agriculture, services and business in general. Indicator 1 of UN SDG7 is to provide universal access to electricity in proportion to the population. While universal electrification is undoubtedly a desirable goal, what this indicator fails to address is the energy need of businesses in a country. Calculating the success of electrification based on the ratio of population versus electrification does not guarantee electrification for all, households and businesses alike. There needs to be a consideration and plan for addressing the comprehensive commercial needs of a country, as modern production of goods and services is heavily based on access to electricity. In other words, an electrification policy needs to address both households and business as a whole. Additionally, there should be sufficient fossil fuel (e.g. coal, petroleum, natural gas) for the electric consumption of the country, preferably, locally produced in order to enhance the energy security of the country (Kurian 2012).

1.5.2 Environmental Consideration

To construct a sound sustainability framework for the energy sector, the sector policy needs to go beyond the concept of the traditional energy security and address environmental concerns (Yao et. al 2014). It has been shown that conventional energy sources are the critical sources of environmental stress (Munasinghe 2002), and the energy sector needs the greatest reform in attempting to respond to climate change (Lundahl 1995). Among the greenhouse gases, which are a major threat to climate change, carbon dioxide is the major concern as it is related to human activities (Duggirala 2010) and counts for around three-quarter of the human-generated warming effect (Stern 2008). Additionally, fossil energy was responsible for 64% of the global anthropogenic CO2 emissions between 1850 and 1990, 89% of global anthropogenic sulfur emissions from 1850 to 1999, and 17% of global anthropogenic methane emissions between 1860 and 1994, all of which drove global environmental changes, including climate change, urban haze and acid deposition (Najam et. al 2003).

Therefore, the second framework is to supplement the missing piece of the first framework of this research by safeguarding the environment in energy production. Hysing (2010) points out the need to increase consideration of environmental values in all policy decision-making within the energy sector. Adams (2006) extensively argues that nations need to treat the environment differently than the economy because the environment is not a by-product of society's activities, unlike the economy. This study investigates the environmental consideration on three grounds: by observing the CO2 emissions of the country – the most responsible polluting agent affecting climate change, transitioning into renewable energy and environmental policy integration into the national energy policy.

1.5.3 Financial Health

Financial health is also critical for the sustainability of the energy sector. As today's society is deeply rooted in a market economy, sustainability in the energy sector comes at a price. Daniel Yergin (2006) shares this idea in his analysis of energy security and argues that energy security has a price, thus it requires to be part of the price of energy and the cost of the country's security. Sustainable Energy for All (n.d.) reports that to achieve universal energy access, a minimum investment of USD 45 billion is required annually until 2030 on a global scale.

An ideal energy sector would be well functioning without financial constraints, nor excessive financial dependence on external sources such as loans from international agencies or those from another country (e.g. China's BRI; the US Marshall Plan; etc.). When considering the price of energy, and in particular electricity tariffs, the affordability to the general public (Kurian 2012, P675) is as important as constructing tariff structures that cover the real costs of the generation, transmission, distribution and maintenance. This applies whether or not governments outsource the generation, transmission and/or distribution of electricity to the private sector. Affordability can be calculated based on the share of household income spent on fuel and electricity (Davidsdottir 2012). On the other hand, a heavily subsidized energy tariff can be a major hindrance for the long-term development of the sector. In brief, a sustainable energy sector would provide affordable energy to the public and yet be profitable enough to perpetuate the energy generation mechanism.

1.5.4 Paper Organization

In order to discuss its proposals, this study presents a literature review in Chapter 3 which reviews the history of a sustainability policy, the profound concept of sustainability and its relation to energy.

Chapter 4 and Chapter 5 study the macro-energy of Myanmar, covering all the major energy sources: coal, oil and gas, hydropower, solar, wind, biomass, etc. In Chapter 4, it projects a macro-overview of the energy sector of Myanmar highlighting all the major energy sources. Chapter 5 addresses energy security on the macro-level – covering both the macro-energy measurements, which include total primary energy supply (TPES) and total primary energy consumption (TPEC), as well as a national energy security policy analysis.

From Chapter 6 on, this paper narrows its scope down to one type of energy: electricity, as it is the most commonly used form of energy in Myanmar. Chapter 6 evaluates the level of electricity security in the country during the study period. Chapter 7 observes, primarily regarding electricity generation, whether or how environmental considerations are integrated into the national energy policy, transitioning into renewable energy, as well as CO2 emissions of the country. Chapter 8 investigates the electricity tariff structures in order to evaluate the financial health of the sector. Each chapter also ends with recommendations for each discussed topic therein. Chapter 9 provides a concluding summary of the research.

1.6 Research Methodology

Sustainability issues in the energy sector are deeply interrelated. This research attempts, from a basic research methodology, to understand this interplay in the energy sector in order and further clarify the level of sustainability in the sector. Purely from a normative policy analysis standpoint, the study investigates the energy-related policies in Myanmar, including but not limited to, various national energy polices, Myanmar Sustainable Development Plan (MSDP), Myanmar Climate Change Strategy (MCCS) and environmental policies in relation to the energy sector.

1.6.1 Data Collection

Due to COVID-19 travel restrictions between Thailand and Myanmar, and further limited access to key Myanmar governmental officials and energy experts residing in Myanmar as a result of the ongoing political crisis, documentary research, desk research, secondary statistics and data from various reliable and reputable sources were heavily relied on. The data and information sources include, but are not limited to previous research, the World Bank, IFC, Ministry of Electricity and Energy, Ministry of Mineral Resources and Environmental Conservation, Ministry of Agriculture, Livestock and Irrigation, Ministry of Education, Directorate of Investment and Company Administration, other relevant Myanmar government agencies, various foreign chambers and business associations in Myanmar, and other international organizations.

Based on the nature of the topic, this qualitative research does not require extensive fieldwork. By relying on the mentioned data sources, this study attempts to critically interpret and analyze data and policies from the broader lens of sustainability herein adopted by the research. To ensure the credibility and validity of the research findings as much as possible given the existing limitations, this study will embody triangulation techniques of Denzin (1970, P301), by using and comparing various sources of data.

1.6.2 Data Analysis

The data analysis of this study is rather simple and straight forward. Taking advantage of a qualitative research method to profoundly understand the topic, secondary statistics and data from various reliable and reputable sources are critically observed and interpreted. Both qualitative and quantitative data, including but not limited to numbers, observations, images from various sources, were analyzed and interpreted in parallel. A normative approach was selected for this study as both opinions and facts were needed (Routio 2007) for the conceptual frameworks: energy security, progressive environmental consideration, and financial health of the sector.

The research analyzed existing energy policy to evaluate its effectiveness and development based on collected data and theories. As this study measured the level of sustainability in the energy sector and its development in Myanmar during a set period by using the conceptual framework as a tool, starting in 2011, which was treated as a baseline for comparison and any obtained empirical material was critically processed and analyzed to produce credible findings.

1.6.3 Research Scope and Limitation

This research studied energy development and sustainability in Myanmar from 2011 to 2020 only. There had been many limitations and constraints to conduct this study due to travel and movement restrictions due to COVID-19 and, moreover, the political unrest and the likelihood of civil war in Myanmar. Additionally, because of the political chaos in Myanmar, internet access had been extremely limited even to conduct virtual interviews, setting aside whether interview invitees would be willing to speak while the whole country was on a strike. Several governmental websites and informational pages had been attacked by hackers. The military junta had also shut down media, news sources and certain informational pages. Moreover, the availability of official data and statistics has been always an issue in Myanmar for any sector. However, there have been several credible reports and publications issued by several international organizations and the Myanmar government itself. By using triangulation methods to analyze the publicly available information and data, combined with knowledge on the major actors and resources, the research has attempted to ensure the credibility of the findings.

CHAPTER TWO
LITERATURE REVIEW

2.1 Sustainability in Energy – A Policy History

The notion of energy sustainability has been shaping the agendas and policies of both developed and underdeveloped countries for a few decades. The issue of global sustainability has also been widely acknowledged by key stakeholders in the international institutions, and it became a common topic of debate among scholars, scientists, journalists and citizens in many parts of the world (Adams 2006).

The concept of energy sustainability emerged on the global agenda mainly in the environmental context (Adams 2006; Baker et. al 2008; Munasinghe 1993 & 2007; Jacobus 2006; Hysing 2010) more than thirty years ago, following the new mandate adopted by IUCN in 1963: the management of natural resources and living species, including humans, to achieve the maximum "sustainable quality of life" (Adams 2006). The concept of energy sustainability was then introduced as a theme agenda at the 1972 United Nations Conference on the Human Environment in Stockholm highlighting the importance of connecting industrialization and economic development with environmental protection (Hysing 2010). During the following decades, the mainstream sustainability concept was progressively developed via the 1980 World Conservation Strategy, the 1987 World Commission on Environment and Development (i.e., the Brundtland Report), the 1992 United Nations Conference on Environment and Development in Rio de Janeiro, Brazil, and 2002 World Summit on Sustainable Development in Johannesburg, South Africa.

Professor Brynhildur Davidsdottir of the University of Iceland outlined in 2012 how energy was brought up to the sustainability agenda of the world. She argued that energy was not addressed in the early discussions of the sustainable development. With the gradual evolution of the sustainable development paradigm, energy was targeted as a source of environmental damages, specifically highlighting the direct link between energy and the environment at the 1972 Stockholm Conference (Davidsdottir et. al 2007; Davidsdottir 2012; Spalding-Fecher et. al 2005). The Stockholm action plan addressed the impact and implications of energy generation and consumption on the environment (Davidsdottir 2012). The discussion was further expanded in the above-mentioned 1992 Rio de Janeiro and 2002 Johannesburg conferences, respectively.

The Rio Declaration on Environment and Development (1992) highlights energy issues as the main theme in Chapter 9 of Agenda 21 (Protection of the Atmosphere) referring to energy consumption as a source of atmospheric pollution (Spalding et. al 2005; Davidsdottir 2012). Additionally, several provisions in other chapters of the Agenda 21 provide direction to minimizing energy use (Chapters 4 and 7), maximizing energy efficiency (Chapters 4 and 7), and driving the development of cleaner energy sources (Chapter 9) by bringing major attention to the interrelation between economic growth and environmental stress (Davidsdottir 2012). The Commission for Sustainable Development (CSD), which was established at the 1992 Rio Conference and is dedicated to studying sustainable development, took up the topic of energy for the first time at its ninth session which spotlighted sub-sectoral issues, such as access to energy, renewable energy, energy efficiency and rural energy. This analysis went beyond the energy generation and consumption versus environmental derogations (Spalding et. al 2005; Davidsdottir 2012). This important step set the basis for the 2002 Johannesburg conference (Davidsdottir 2012), which was one of the largest gatherings of politicians, stakeholders, lobbyists, public officials, media, and researchers (Dryzek 2005). At this conference, participants were able to link the issues of energy to the three pillars of sustainable development: the economy, the social order, and the environment (Davidsdottir 2012). Davidsdottir (2012) and Najam et. al (2003) have argued that the journey of integrating energy with sustainable development needs to address its three pillars:

a) identifying the relationship between energy and the environment, which was achieved at the 1972 Stockholm conference;
b) determining the connection between energy and the economy, as outlined at the 1992 Rio de Janeiro conference; and
c) recognizing the link between energy and society, which was studied at the 2002 Johannesburg conference.

Thus, energy generation and consumption became a standalone issue rather than a subset of other issues, crosscutting the three pillars of sustainable development (Davidsdottir 2012).

Table 1. The Connection between Energy and the Three Pillars of Sustainability

<table>
<tr><th></th><th>Environmental
(energy as a source of environmental stress)</th><th>Economic
(energy as a motor of macroeconomic growth)</th><th>Social
(energy as a requisite for basic human needs)</th></tr>
<tr><td>Stockholm (1972)</td><td>Main focus on ‘environmental effects’ of energy</td><td></td><td></td></tr>
<tr><td>Rio de Janeiro (1992)</td><td colspan="2">Main focus on balancing the Environmental-Economic aspects of energy supply and use</td><td></td></tr>
<tr><td>Johannesburg (2002)</td><td colspan="3">Focus expands to include all three dimensions: Energy is linked directly to the Millennium Development Goals and poverty eradication; the need to consider the needs of the poorest becomes the added social compulsion</td></tr>
</table>

Source: *Najam, A. and Cleveland, C. (2003), p.134.*

Although setting sustainable development as a political agenda through international declarations and agreements makes national governments responsible for this agenda’s adoption and implementation, the extent to which and by what means sustainable development has actually been implemented varies among countries (Hysing 2010). Myanmar’s government adopted this agenda item after the 1992 Rio de Janeiro conference (H.E. Aung 2002). Various Myanmar government agencies inserted sustainable development as a goal, at first, in the 2009 National Sustainable Development Strategy (NSDS), then in the 2018 Myanmar Sustainable Development Plan (MSDP), the latter of which includes multiple strategies and action plans related to the energy sector (MSDP 2018). The MSDP, which has 3 Pillars, 5 Goals, 28 Strategies and 251 Action Plans, which include the UN’s SDG, it also embodies the essence of the 12 Point Economic Policy of Myanmar (July 2016), as well as the Greater Mekong Subregion Strategic Framework and the ASEAN Economic Community (MSDP 2018).

2.2 The Complexity of the Concept of Energy Sustainability

One of the concepts that is widely discussed in development studies is the concept of sustainability. Sustainable development, a concept that emerged on the basis of a growing awareness of climate change, is arguably elusive and multidisciplinary (Adams 2006; Baker et. al 2008; Munasinghe 1993 & 2007; Jacobus 2006; Hysing 2010). Sustainability covers a range of complex meanings and is being applied today in many other aspects of society, such as sustainable growth, sustainable production and consumption, sustainable fashion, sustainable citizenship (widely discussed by Micheletti et. al 2012), and so on.

One of the most quoted definitions of sustainability comes from the Brundtland Report (Emas 2015):

> "*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*." (WCED 1987)

While the message is elegantly conveyed, the definition is widely criticized for its looseness in defining what "needs" are and the time frame for "generations." Adams (2006) argues that one reason for the common acceptance of the notion of sustainable development is due to its looseness. He continues that the notion can be used to represent divergent ideas, and thus, it may seem to bring governments together, but may not necessarily assist them to agree on goals.

> "*In implying everything sustainable development arguably ends up meaning nothing*." (Adams 2006)

Qizilbash (1998) lists a number of various definitions of sustainable development by different scholars, from pure environmental protection (moderate ecocentrism), to anti-capitalism, and to addressing the whole world's life support system (extreme ecocentrism). Some scholars' belief and approach, for instance Powrie and colleague (2000), would fall under the responsible capitalist ideology, or anthropocentrism: accelerating economic growth and employment, addressing societal needs, protection and sensible use of natural resources.

Along the various definitions and implications of sustainability, one question that has been debated is whether sustainability is, or can actually be "sustainable." Adams (2006) discusses the environmental limits and human footprint in the ecology. One of his argument's foundations is that the global ecosystem came with limited resources. As such, the limit of growth for humanity has been predestined. As per the report of the Global Footprint Network 2020, humanity has overconsumed the earth's biocapacity since the 1970s. With the increase consumption rates, today we need one and a half earths to provide our needs and absorb our waste (Global Footprint Network 2020). In 2020, the Earth Overshoot Day (the day we use more natural resources than the planet can regenerate in the whole year) is on August 22 (Global Footprint Network 2020). Even though green consumption has recently been trendy, there is no such thing as a consumption that is absolutely safe or has no ecological impact. Any consumption including "green consumption" is still consumption (Robbins et. al 2014). Same things apply to the energy sector. There is no energy generation without risk or waste, regardless of the energy sources used, whether they are renewable or not (IAEA et. al 2005). Even if modern technology does not emit pollutants at the point of energy use, waste and emissions may be linked with its generation along all energy chains or other parts of the energy life cycle (IAEA et. al 2005). Therefore, the idea of sustainable development is not to grow without limits, but rather to grow within limits. In Adams' words (2006), sustainability is a sensible way in dealing with the unavoidable trade-offs between environmental, social and economic dimensions.

The idea of integrating the three pillars of environment, economy and society in sustainable development was proposed by economist Rene Passet in 1979 (Kongoli 2016). While scholars and actors came to agree theoretically regarding the need to integrate the three pillars (Banuri et. al 1994; Najam et. al 2003), there are also several scholars who proposed adding a fourth pillar, such as culture, institutions, governance, technology etc. (Purvis et. al 2018).

Such elusive and subjective term as "sustainability" has been measured, in general, by scholars and institutions in their own respective ways without commonly accepted approaches. The traditional way of measuring sustainability is through measuring economic growth (Emas 2015). Scholars, such as Daily et. al (1992), base their criteria mainly on the carrying capacity of the Earth. Both renewable and non-renewable resources are sub-classified by Daily into "substitutable" and "essential". Substitutable resources include some metals, some minerals, fossil fuels and some natural fibers. Essential resources include fertile soils, biodiversity, and fresh water. According to Daily's concept, some resources could fit under both categories based on the way they are consumed. For instance, forests can be substitutable if being treated as a source of wood, however, treating forests as a source of ecosystem services would make it fall under the essential resources category. Based on this concept of whether or how easy a resource is substitutable, Daily produce a matrix of maximum sustainable level of use (MSU) and maximum sustainable abuse (MSA) in order to have sustainable consumption of resources. While this is a very practical way to measure and predict sustainability, it is too ecology-oriented and fails to address the critical role of social, economic and political factors.

Munasinghe's (2007) way of measuring sustainability is a more multi-disciplinary approach through a system which he calls "sustainomics." His approach is based on treating sustainable development as a process, rather than as an end point and, more importantly, as a measure of "progress." He argues that traditional economic evaluation does not lead to sustainability, even though the concept of integrating economic, social and environment is present. The traditional economic evaluation attempts to measure the three dimensions in monetary value by a cost-benefit analysis (CBA) to only test for feasibility (Munasinghe 2007). The issue is that CBA is based on the "concept of optimality," which differs from sustainability, and such economic valuation is often difficult to undertake (Munasinghe 2007). Munasinghe's sustainomics involve a core framework of "making development more sustainable" (MDMS) which focuses on identifying and eliminating the easily identifiable unsustainable activities. MDMS metric uses indicators which have diverse measurement and relevant sustainability criteria. Certain sustainability indicators, however, may worsen while others improve. In those cases, a verdict is needed to trade-off one indicator for another. However, this trade-off is what concerns Adams's (2006) concept of sustainability.

Adams's (2006) way of achieving sustainability is rather straight forward. In his view, there is no sustainability because when governments and businesses must make trade-offs between the environment, economy and society, environment generally comes out last. According to him, while the economy is a byproduct of our society, the environment is not. Additionally, the environment supports both the economy and society (Adams 2006). Adams found, therefore, that the three pillars (environmental, social and economic) cannot be treated equally. By emphasizing the importance of the environment in all levels of decision making, sustainability can be achieved (Adams 2006). Hysing (2010) has a slightly different view on approaching sustainability, by looking to find a balance between environmental protection, economic development and social justice. This "balancing" is defined as increasing consideration of the environmental values in policy making (Hysing 2010). It is not surprising that different scholars use different rules and criteria for sustainability, based on their interpretation of the concept. There is not one conceptual framework that can capture the whole concept of sustainability (Munasinghe 2007).

Similarly, sustainability in the energy sector has been studied widely and quite differently without commonly accepted frameworks, nor definitions (Grigoroudis et. al 2019). The study of sustainability in the energy sector is rather straightforward – developing criteria and indicators and measuring sustainability of the sector through them (Grigoroudis et. al 2019; IAEA et. al 2005). Grigoroudis and colleagues (2019) extensively discuss fourteen different ways of studying sustainability in the energy sector by renowned international institutions and scholars (see below table). Some studies are widely eclectic while focusing on certain specific areas. The indicators used therein, or their respective approaches vary, ranging from including the three dimensions of social, economic and environment to focusing on energy access and efficiency. Even though these approaches of studying sustainability in energy are practiced by many countries and institutions, none of them are free from criticism on the ground of insufficient coverage of energy sustainability (Grigoroudis et. al 2019).

Table 2. Different Methods of Studying Sustainability in Energy

Studies	Methods	Dimensions
International Atomic Energy Agency	Use of 11 indicators	Health, affordability, accessibility, disparities in energy supply and demand, energy production, use, supply, efficiency, intensity, security, diversity, pricing, taxation, pollution, waste generation, land degradation, climate change and deforestation.
OLADE	Use of 8 indicators	Energy autarky, soundness, productivity, electricity coverage, coverage of basic energy needs, CO2 emissions, share of renewables, depletion of fossil fuels and firewood.
Energy Development Index (EDI)	Use of 4 indicators	Per capita commercial energy consumption, per capita residential electricity consumption, share of modern fuels in residential energy consumption, share of population with access to electricity.
Sustainable Energy Development Index	Use of 11 indicators.	Economic, social, environmental, technical and institutional of intra- and inter-generational needs

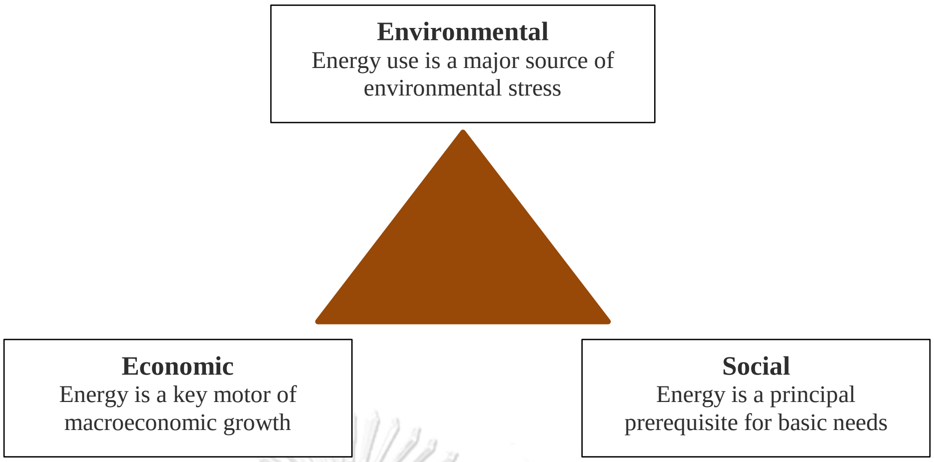
(SEDI)		
Regulatory Indicators for Sustainable Energy (RISE)	Grading system. Scores range from 0 to 100.	Energy access, energy efficiency, use of renewable energy
SDG7	Use of targets and indicators	Energy access to affordable, reliable, sustainable and modern energy for all
Energy Trilemma Index	Grading with A, B, C, D where AAA is for highest performance.	Energy security, quality of supply, access, resilience, affordability, competitiveness, emissions, productivity, macroeconomy, transparency, corruption, political stability and innovation.
Energy Architecture Performance Index (EAPI)	Use of 18 indicators	Economic growth, environmental sustainability, energy access and security
Energy Justice Metric	Use of 11 indicators	Energy equity in the U.S., China and EU.
Energy Security Measurement Framework	Use of 20 components	Availability, affordability, technology development, sustainability and regulation.
Multidimensional Energy Poverty Index	Use of 6 indicators	Use of modern fuel for cooking, indoor pollution, electricity access, ownership of household appliances, ownership of entertainment and education appliances, access to information and communication services.
Framework of Narula and Reddy	Analytic hierarchy process	Energy supply, conversion, demand, distribution, efficiency availability, affordability, and environmental acceptability.
Energy System Evaluation	Three-step assessment framework	Energy efficiency investments by integrating environmental, financial and risk indicators
Sustainability Assessment by Fuzzy Evaluation (SAFE)	Ranking scheme	Environment, human system, economy, energy system, security

Source: Grigoroudis et. al 2019

The relation of energy to the three dimensions of development is rather remarkable. Munasinghe (2002) states that energy is paramount to any conversation of sustainable development because it is central to all three pillars. In its relation to the economic pillar of sustainable development, energy is responsible for the growth of the macroeconomy as it fuels that mechanism. In support of this, Najam et. al (2003) and Payne (2010) find that there is a correlation between energy use and economic growth. Energy prices are also greatly responsible for inflation and unemployment which are fundamental to the economy (Hooker 1999). In its relation to this social pillar, energy is a necessity to satisfy many basic human needs and services (Rao et. al 2017). Broad access to energy, particularly electricity, advances human wellbeing (Grigoroudis et. al 2019), as it improves health conditions and employment opportunities which boost equity among the population and also benefits the wider context of human development (Grigoroudis et. al 2019; IAEA et. al 2005). Kurian (2012) finds that energy poverty is an obstacle to sustainable development (Kurain 2012; Grigoroudis et. al 2019). In effect, Najam (Najam et. al 2003) stated that about 100 watts/capita could help achieve a reasonable quality of life, including access to clean, safe, efficient cooking, sanitation, water and home electrification. This 100W figure is merely one tenth of the required energy that support the Western European living standard with modern technology (Najam et. al 2003). In its connection with the environmental pillar, traditional energy sources are the critical sources of environmental stress at the local and global levels (Munasinghe 2002; Grigoroudis et. al 2019), as energy generation produces air pollution, leads to land degradation and causes climate change (Grigoroudis et. al 2019). Fossil energy was responsible for 64% of the global anthropogenic CO2 emissions from 1850 to 1990, 89% of global anthropogenic sulfur emissions from 1850 to 1999, and 17% of global anthropogenic methane emissions from 1860 to 1994, all of which drove global environmental changes including climate change, urban haze and acid deposition (Najam et. al 2003).

Energy itself is not a “need” in absolute terms, however, it is utterly crucial to achieve adequate living standards, water, food, education, health care, employment and shelter (Najam et. al 2003). Therefore, Najam et. al (2003) argue that even if energy does not have any impact on the environment whatsoever, it would still be a key issue for sustainable development policy on the economic dimension alone.

Figure 2. The Relation of Energy and the Three Pillars of Sustainability



Source: *Najam, A. and Cleveland, C. (2003), P. 119*

The UN's approach in targeting and measuring sustainability identifies seventeen goals with 169 targets and 247 indicators, twelve of which are repeated under two or three different targets (UN Sustainable Development Goals 2015). These seventeen SDGs are formulated as a follow-up agenda for the yet unreached Millennium Development Goals (2000-2015), due to be accomplished by 2030. According to Mensah (2019), the SDGs represent five overarching themes: "people, planet, prosperity, peace and partnership" under the umbrella of the social, environmental and economy dimensions. One notable critique towards SDGs is the fact that these goals are not only interrelated but also interdependent, which further escalates wider trade-offs requiring the participating nations to react (Mensah 2019; Rao et. al 2017). A couple of examples given by Mensah (2019) are that if forests are cut down for agricultural purposes in order to have food security, biodiversity could be endangered, or food security could be threatened if crops are converted to biofuel for energy security. This captures the difficult balancing of the three pillars of sustainable development goals. Therefore, a good understanding of the interdependence between energy and SDGs is crucial to be able to implement them successfully (Rao et. al 2017).

The first source of energy since the dawn of time is the sun, as it provides light and heat during the day ("The History of Energy," n.d.). As human society evolved, people enhanced their use of energy. From relying first, through the Middle Ages, on firewood, dung, charcoal, animals, wind and human power as a source of energy (Allen 2013), people moved on, during the industrial revolution, to coal, subsequently followed by the discovery of electricity in 1752 and the invention of the first coal-powered steam engine in 1769 ("The History of Energy," n.d.). Since then the energy sector has tremendously evolved, generating energy becoming inseparable from a modern economy and society. Because of technological innovation, advancement and globalization, any production and consumption today directly or indirectly require energy (Asghar 2008; Mahalik et. al 2014). Especially during a pandemic, like Covid-19, energy becomes vital in treating patients while saving lives through the proper distribution of safe and effective vaccines. As physical schools are closed due to the pandemic, online learning requires electricity and connectivity, to just mention a few examples.

One of the most relevant forms of final energy for everyone is electricity. Rao and Pachauri (2017) study the relationship between per capita and nationwide electrification in ten countries. Their study finds that only when the country's average income reaches a certain point (in their finding, about GK $15-$20 per capita per day), a country's electrification reached more than 90% of the population. An exception is China, which achieved universal electrification at a lower income level with less than GK $10 capita/day. Rao and Pachuari conclude that income levels of a country do not necessarily imply that a country requires a certain financial capacity to extend access to electrification in the country. However, a country's average income level may reflect at what development stage governments give priority to electrification (Rao et. al 2017).

The global energy consumption has increased around six times since a century ago (Pîrlogea et. al 2011). It is widely agreed by scholars, economists and policy analysts that energy plays a critical role in a nation's consumption and production. However, strong correlation between energy use and economic growth does not imply a causal relationship between them (Payne 2010). The study of how energy consumption and economic growth co-relate started rather late. Acaravci (2010) points out that the first scholars to study the subject were Kraft and colleague in 1978, when they determined that there was a unidirectional relationship from GDP growth to energy consumption in the US. Whether economic growth precedes energy consumption or whether energy per-se is a catalyst for economic growth has stimulated debates among policy analysts and economists (Acaravci 2010; Pîrlogea et. al 2011; Mahalik et. al 2014).

The study of the relationship between electricity consumption and economic development can be grouped into four hypotheses (Acaravci 2010):

1) **Growth hypothesis**: electricity consumption drives economic growth and any reduction or increase in consumption will lead to a decrease or increase in income.
2) **Conservation hypothesis**: an economy does not depend on energy development and any energy conservation will have no or little effect on economic growth.
3) **Feedback hypothesis**: there is a bi-directional relationship between economic development and electricity consumption.
4) **Neutrality hypothesis**: indicating no relationship between energy consumption and economic growth.

Based on these hypotheses, Payne (2010) conducted an extensive study of more than 100 countries. He concluded that just over 31% of them supported the neutrality hypothesis, while 27% supported the conservation hypothesis, 22% supported the growth hypothesis and, finally, 18% supported the feedback hypothesis. Payne's research also showed empirical results which produced mixed results in terms of the four hypotheses (neutrality, conservation, growth, and feedback) related to the causal relationship between electricity consumption and economic growth. The study of Mahalik and colleague (2014) of G7 countries i.e., the United States, United Kingdom, Canada, Japan, France, Germany and Italy, as well as Taiwan, Korea, Nigeria, Tanzania, Ukraine, Russia, Poland, plus an additional six Asian countries: India, Pakistan, Malaysia, Singapore, Indonesia, Philippines, also proves that there is no single hypothesis that would be applicable for all countries. This finding merely indicates that energy is deeply relational to many aspects of the economy and society and, thus, it requires a multidisciplinary approach to its study. Consequently, a partial study or a study of its relationship with a single area may produce a distorted picture.

While it is impossible not to find an energy footprint in the production and consumption activities of today's modern life, certain actions and methods are much safer and have fewer negative impacts on the environment and the ecology as a whole. Currently the world energy is still mainly based on fossil resources (Tvaronaviciene et. al 2020). As numerous studies have shown that the easily accessible fossil sources today will dry up, sooner or later, and fossil fuel prices will increase due to difficult accessibility to the resources and resource scarcity in the future (Tvaronaviciene et. al 2020), nations need to transition into renewable energy production which has more environmental and economic benefits. Moreover, by transitioning into renewable sources, nations can have a strong energy security (Jakstas 2020). Renewable energy sources (RES) are continuously being rejuvenated in nature and their resources include solar, hydropower, wind, tides, geothermal, bioenergy, biofuels, etc. (Tvaronaviciene et. al 2020). Adopting RES became a popular trend in the early 21st century among RES pioneer countries: Spain, Australia, Germany, Spain, the U.S. and later China (Tvaronaviciene et. al 2020). The renewable energy generation accounted for about 19.5% of the global electricity from 2012 to 2017 (Tvaronaviciene et. al 2020). In 2012 alone, out of a total energy production of 1373 GW, hydropower was 990 GW, followed by wind (283 GW), and solar 100 GW, respectively (Tvaronaviciene et. al 2020). The investment in the new RES was also increased by 13% from 2012 to 2017 (Tvaronaviciene et. al 2020). RES has several benefits for the sustainability of the energy sector as well as the sustainability of the economy. However, RES does not come without flaws or disadvantages. Below is a list of the RES advantages and disadvantages (Gaille 2017):

Advantages of RES:

- RES is safer and cleaner when compared to fossil fuel: coal, petroleum, natural gas.
- Abundant and exists in multiple forms, such as solar, wind, tides etc.
- Its maintenance requirements are lower.
- It saves money over a long term.
- More health and environmental benefits.
- May lower reliance on foreign energy sources.
- It requires technology only, not fuel.

Disadvantages of RES:

- It has geographical limitation and thus may not be commercially viable.
- It relies on the natural supply and has intermittency.
- May require energy storage due to its intermittency, which could be expensive and has its own environmental costs.
- Higher upfront cost as its facilities may be more expensive
- Pollution is still generated, even though it is greener.

Climate change is “global in its origins and in its impacts” (Stern 2008). Due to its alarming increased scale (Andrade et. al 2015), the incremental climate change calls for an effective response and collaborative efforts to reduce emissions of greenhouse gases (GHG) including CO2, CH4 and N2O (Ayalon et. al 2001). Of the six major GHG covered by the Kyoto Protocol of 1997, carbon dioxide is the main concern as it is mainly connected to human activity (Duggirala 2010) and counts for around three-quarters of the human-generated warming effect (Stern 2008). The energy sector needs the greatest reform in the attempts to respond to climate change (Lundahl 1995). Energy and climate change are bi-relational (Jakstas 2020). Due to less “ethical” or massive generation of nonrenewable energy, climate change is affected triggering excessive precipitation or drought, escalation of sea levels, recurrent and severe events etc., which later impact the generation of energy and energy security. For instance, a warmer temperature caused by climate change would negatively impact the generation of hydropower, plant life and even fossil fuel and nuclear power plants as they require water for cooling which will affect output (Jakstas 2020).

2.3 World Energy Outlook & SDG 7

In their extensive overview of the world energy sector’s future, Tvaronaviciene and colleagues (2020, P1) project several key features while quoting several leading sources, including the World Energy Council, the World Energy Development Scenarios for Energy Experts, IEA, REN21 etc. For example, in the past four decades, the world economy has scaled up by about 3.3 times: an average increase of 3.8% from 1971 to 1980; 3.0% from 1980 to 1990; 2.8% from 1990 to 2000; and 2.6% from 2000 to 2011 per annum (Tvaronaviciene et. al 2020, P3). Since

2011, the global economy has a moderate increase and was estimated to remain stable at 3%/year in 2018 and 2019 (Tvaronaviciene et. al 2020, P46). Along with the growth of the global economy, the demand for energy increased globally.

The worldwide consumption of primary energy increased by about 10% compared to 2010 and 2017 with the highest consumer being the Asia Pacific region (5743.6), followed by North America (2772.8), Europe (1969.5), Commonwealth of Independent States (978) and the Middle East (897.2) (Tvaronaviciene et. al 2020, P46). "Primary energy" is the energy that is obtained directly from natural resources which can be classified into renewable and non-renewable (finite) sources. Renewable energy sources include solar, hydropower, wind, tides, geothermal etc. whereas non-renewable energy sources are fossils: natural gas, coal, oil, nuclear fuel (uranium and plutonium etc.) and peat.

While the future energy demand has been calculated differently by various sources, if the current consumption trends continue, the world's primary energy consumption is predicted to increase 44% by 2035 compared to the consumption amount in 2011 (Tvaronaviciene et. al 2020, P46). Mahalik and colleague (2014) base their forecast on the 2007 report of International Energy Agency (IEA) that the primary energy demand worldwide will grow at an average annual rate of 1.8% from 2005 to 2030. Mahalik and colleague (2014) estimate that 74% of the increase in global primary energy demand by 2030 will be contributed by developing countries – China and India alone would account for about 53% of the increased demand. Currently, three large-nations (U.S., China and Russia) consume 41% of the world's primary energy, whereas those three countries possess only about 38% of the world's primary energy sources (Tvaronaviciene et. al 2020, P2). It is also forecasted that the use of renewable energy in both developing and developed countries will outgrow the use of nuclear energy by 2035 (Tvaronaviciene et. al 2020, P46).

The UN's sustainable development goal 7 enshrines the "access to affordable, reliable, sustainable and modern energy for all" by 2030 (UN SDG). While this goal has a higher chance of success in developed countries within the set time frame, it is rather too ambitious for developing countries like Myanmar. As many developed countries have achieved quasi-universal electrification already, their responsibility is to focus on transitioning into renewable and more environmentally friendly generation and distribution of electricity while meeting the increased demand of both existing and new population. For developing countries, accelerating access to electricity and environmental conservation need to be addressed in parallel for the existing population's increased demand, and for the new population.

Even though the worldwide electrification has increased, there are still more than 840 million people without electricity (UN Forum 2019). The UN Forum (2019) projects that even if the global electrification rate increases 0.86 pp annually between 2018 and 2030, there will still be about 650 million people without electricity in 2030 and 9 out of 10 of them will be in sub-Saharan Africa.

CHAPTER THREE
MYANMAR ENERGY PROFILE

3.1 Energy Sources in Myanmar

Myanmar's energy resources can be categorized into renewable and non-renewable. The former includes hydropower, solar, wind, tidal, geothermal and biomass, while the latter include coal, oil, natural gas and fossil materials.

3.2 Oil and Gas

Myanmar is known to be one of the first countries in Southeast Asia to have had a national oil and gas industry (ADB 2016). This sub-sector has a huge growth potential, and its offshore production is the most important source of export earnings (ADB 2012), with annual revenues of about USD 1.5 billion, representing 40% of the country's total export earnings (EuroCham 2018). Around 80% of this revenue comes from the offshore natural gas production alone (Irrawaddy April 2021). In 2016, Myanmar's natural gas reserves (6.58 trillion cubic feet as per the report of ERIA 2020a) were ranked 39^{th} globally with a total estimated value of USD 75 billion, which is equivalent to the country's total annual GDP (CIA 2016, cited in Vakulchuk et. al 2017). Myanmar is one of the world's oldest oil producers, having exported its first barrel of crude oil in 1853 (ERIA 2019). No new oil reserves, however, have been discovered during the past 25 years (ADB 2016). The country has licensed 53 oil and gas blocks onshore, and 51 blocks offshore (Ministry of Electricity and Energy 2017). 24 out of 51 offshore sites are classified as deep-sea blocks and 18 are currently in operation. The offshore gas production started in 1998 (ADB 2016). Currently, Myanmar's oil reserves are estimated to be 105 million barrels (ERIA 2020a). Crude oil is mainly produced from the onshore Salin basin and offshore Yetagun field, whereas natural gas is sourced from four offshore fields: Yadana, Shwe, Zawtika and Yetagun (OBG 2020).

Table 3. Existing Offshore Gas Fields and Production

No	Project	Established	Partners	Daily Production
1	Yadanar	Discovered in 1980. Production began in 1998. Estimated reserves between 5.7 Tcf and 162 Bcm	Total (31%) Chevron (28%) PTTEP (26%) MOGE (15%)	850 Mcf; 650 Mcf for export 200 Mcf for domestic use
2	Yetagon	Discovered in 1992. Production began in 2000. Estimated reserves of 3.16 Tcf	Petronas (42%) Nippon (19%) PTTEP (19%) MOGE (20%)	200 Mcf; For export only
3	Shwe	Discovered in 2005. Production began in 2013.	Daewoo (51%) ONGC (17%) GAIL (8.5%) Kogas (8.5%) MOGE (15%)	500 Mcf; 400 Mcf for export 100 Mcf for domestic use
4	Zawtika	Discovered in 1997. Production began in 2014.	PTTEP (80%) MOGE (20%)	300 Mcf; 200 Mcf for export 100 Mcf for domestic use

Mcf = million cubic feet, Bcf = billion cubic feet, Tcf = trillion cubic feet
Source: Ministry of Electricity and Energy 2017 cited in EuroCham 2020

Myanmar's natural gas production is mainly exported to Thailand and China. In 2017, about 1,800 million cubic feet was produced and 70% of the total production was exported (Ministry of Electricity and Energy 2017). Domestic gas consumption is primary for 20 gas-fired electricity-generation plants (60% of total gas in 2011, and 75% in 2017), fertilizer production (12%), and compressed natural gas (10%) (ADB 2012).

Table 4. Daily Natural Gas Production

No	Sites	Daily Production
1	Offshore	1,750 Mcf
2	Onshore	50 Mcf
	Total	1,800 Mcf

Mcf = million cubic feet
Source: Ministry of Electricity and Energy 2017

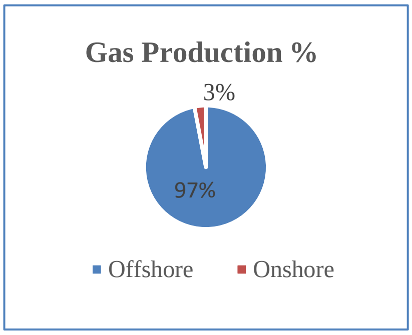


Table 5. Daily Natural Gas Consumption

No	Consumption	Amount
1	Export (Thailand)	950 Mcf
2	Export (China)	400 Mcf
3	Domestic Consumption	400 Mcf

Mcf = million cubic feet
Source: Ministry of Electricity and Energy 2017

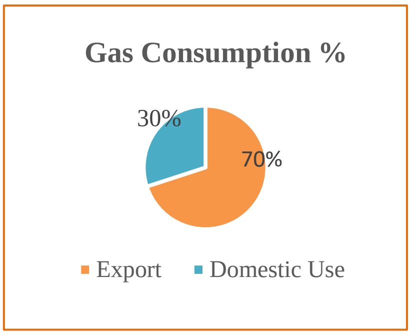


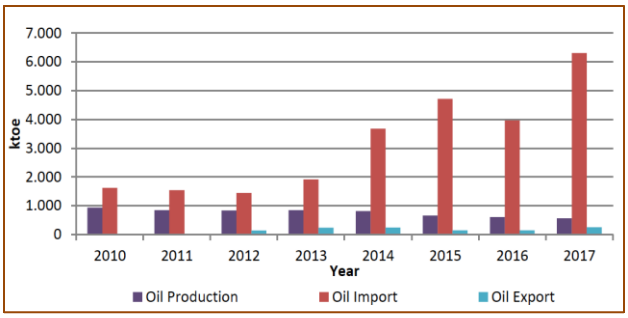
Table 6. Domestic Consumption of Natural Gas

No	Consumption	Percentage
1	20 gas-fired plants	60%
2	Fertilizer production	12%
3	CNG	10%
4	Others	18%

Source: ADB 2012

Myanmar’s crude oil production has been declining by about 7% per year between 2010 and 2017 (ERIA 2018), reaching about 8,000 barrels per day in 2021 (Trading Economics 2021). The oil refinery output declined by about 13% from 2010 to 2017 (ERIA 2018). The average crude oil production has been about 15,000 barrels per day from 1993 until 2020, reaching its highest level in 2006 at about 23,000 barrels per day (EuroCham 2018; Trading Economics 2021). As the country does not produce enough oil to meet its domestic gasoline and diesel fuel demand, it imports about 95% of its total oil demand (Global New Light of Myanmar May 2018): 600,000 tonnes (200,000 gasoline and 400,000 diesel) a month (Myanmar Times April 2018).

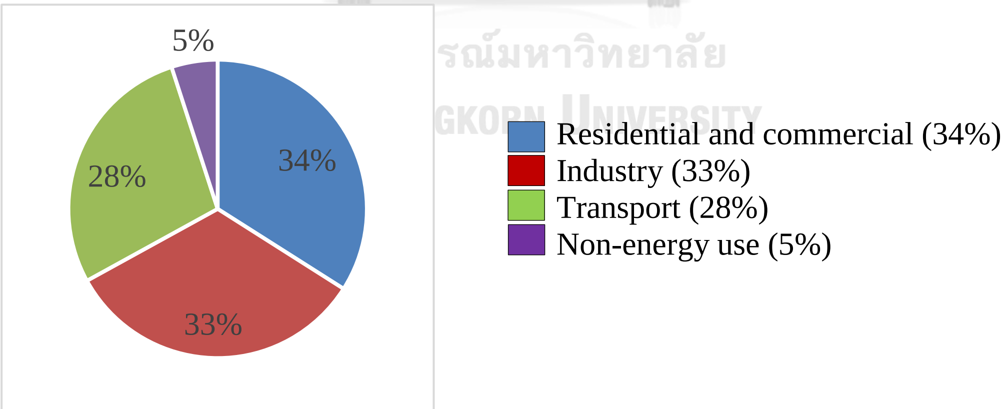
Figure 3. Oil Production, Import and Export (ktoe)



Ktoe = kiloton of oil equivalent
Source: ERIA 2018

The total oil demand of the country increased at an average annual rate of 21% from 2010 to 2017 (ERIA 2018). However, if one removes the demand for international aviation and ships, Myanmar's actual domestic demand increased at an average annual rate of 16%, as the economy of the country grew (ERIA 2018). Between 1971 and 2017, oil has been mainly consumed, on average, by industry (33%), transport (28%), residential and commercial sectors (34%), and non-energy use (5%) (ERIA 2018). Myanmar does not use oil for electricity generation.

Figure 4. Oil Consumption by Sector



Source: ERIA 2020a, p33

There are only three small oil refineries in Myanmar: Thanlyin Refinery, Chauk Refinery, Thanbayakan Refinery, with a capacity of 20,000 barrel of oil per stream day (BOPD), 6,000 BOPD and 25,000 BOPD, respectively. Thanlyin, however, has been shut down at the end of 2016 (ERIA 2018). The plants are old, and they were underperforming, at a rate between 33% to 57% of their respective capacity (ADB 2012). There are 3 liquefied petroleum gas (LPG) plants in Myanmar, with a total capacity of 42-50 MMCFD (ADB 2012). LPG is mainly used for cooking purposes.

Myanmar has a 4,100 km domestic oil and gas pipeline network operated by MOGE (ADB 2016). MOGE distributes natural gas via two pipelines: an onshore national pipeline system (6-24-inch diameter) and a 410-km (24 inch) offshore pipeline from Yangon to the Thai border. This latter pipeline transports 200 mcf per day, which could be increased up to 250 mcf per day if the Thai domestic market can absorb more supply (ADB 2016). As of 2011, there were 50 CNG refueling stations in the country – 42 in Yangon, 2 in Mandalay, 4 in the Yenangyaung field and 2 in the Chauk field (ADB 2012). According to ADB (2012), Myanmar had more than 27,000 CNG-powered busses and cars.

The oil and gas sub-sector has been opened up for private participation in joint ventures and production sharing since 1988 (ERIA 2019), including the importation and construction of storage tanks (ADB 2012). Due to several factors, including international sanctions, obscure regulations, inadequate investment etc., the country's upstream sector was still in its infancy in 2019 (ERIA 2019). After the removal of several sanctions by the United States and the EU, while Myanmar reformed its FDI laws prior to the February 2021 coup, several international companies participated in the sector (ERIA 2019).

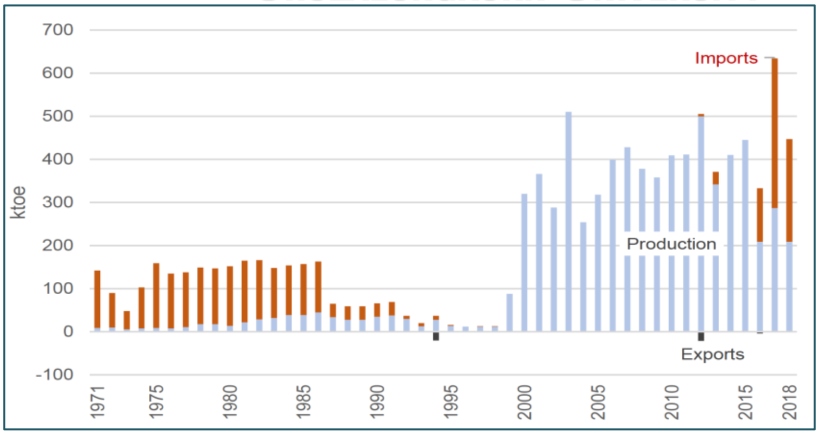
As an effort to mitigate climate change and increased use of domestically produced natural gas, the Union government launched in 1986 compressed natural gas (CNG) and natural gas vehicle programs (ADB 2012). As of 2011, more than 50 CNG refueling stations existed in Myanmar – 42 in Yangon, 2 in Mandalay, 4 in Yenangyang field and 2 in Chauk field (ADB 2012). Over 27,000 buses and cars were converted to CNG vehicle (ADB 2012). On the industrial use of natural gas, there are five urea fertilizer factories with a total capacity of over 2,000 metric tons per day, depending on the availability of natural gas (ADB 2012). As of 2011, 261 out of 273 petrol stations had been privatized (ADB 2012).

3.3 Coal

Coal is one of the sub-sectors that has been under-explored due to lack of investment in the sector and the remoteness of the deposits (ADB 2016). Even though coal creates environmental concerns, it is still one of the cheapest and most readily available sources of energy in Myanmar (OBG 2020). Coal exploration was started during Myanmar's monarchic regime in the 19th century (ADB 2015b). To date, about 565 potential coal mining sites were identified (ADB 2016), mainly in the Shan State (OBG 2020), Sagaing Region, Magwe Region, and Tanintharyi Region (ADB 2012). Coal reserves in Myanmar are estimated at 542.56 million tons (ERIA 2020a), however, only one percent of these identified reserves are set to be mined. Coal in Myanmar is generally low-quality lignite and subbituminous (ADB 2016).

Before new environmental protection regulations were introduced by the Union government in 2015, domestic coal production had significantly increased since 2000, reaching its peak in 2007 with about 1,400 thousand tons, but declined since then to around 700 thousand tons per year in 2013 (ADB 2016). The resulting gap was filled with imported coal to meet domestic demand (ERIA 2020a). Between 1988 to 2009, Myanmar mined an annual average of 500,000 tons (ADB 2015b). About 81% of coal production was exported to China and Thailand in 2005 (ADB 2015b). Coal production was planned to increase by 16% annually, reaching 2,761 thousand tons by 2016 and 5,654 thousand tons by 2031 (ADB 2012).

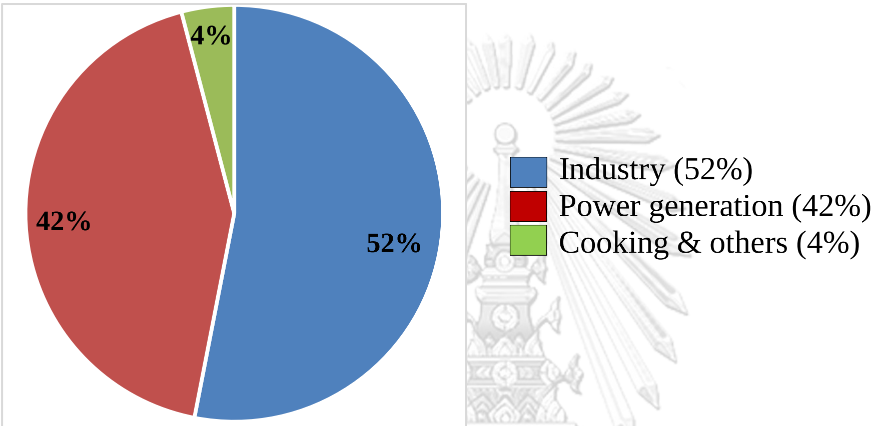
Figure 5. Trajectory of Coal Supply Balance



Kktoe = kilotons of oil equivalent
Source: ERIA 2020a, p44

Coal demand in Myanmar fluctuates broadly every year (ERIA 2020a). As of 2011, its domestic consumption is distributed 42% for electric power generation (the sole Myanmar coal-fired power plant, approved in 2002, is in Tigyit, southern Shan State, with a generation capacity of 120-MW), 52% for cement and other industrial uses and 4% for household use, mainly cooking and heating and other miscellaneous uses on the basis of 98% (ADB 2012).

Figure 6. Coal Consumption by Sector



Source: ADB 2012

The electricity generated by the Tigyit coal-fired plant contributes around 2% of the total electricity generated in Myanmar (EuroCham 2020). Nevertheless, the Thein Sein government had planned to increase the share of coal power from 2% as of 2018 to over 33% by 2030 (MNEP 2014), by signing 11 contracts for coal-fired plants. These contracts, however, were cancelled by the NLD government due to public objections (EuroCham 2020).

As of 2011, 32 private companies were issued 43 coal production licenses (ADB 2012) by the Ministry of Mines during the Thein Sein government. Subsequently, there have been no new coal-fired electric power generation projects approved by the Union government (EuroCham 2020).

3.4 Renewable Energy

Renewable energy sources include hydro, wind, solar, biomass, geothermal and tidal energy. Myanmar has a total renewable energy capacity of about 120,000

MW, with the highest potential in hydropower (100,000 MW), followed by wind, solar and bioenergy (Tun 2019).

3.5 Hydropower

Myanmar is one of the top five countries globally in terms of untapped hydropower potential (EuroCham 2020). Among the renewable energy sources, hydropower is the only large-scale resource which is being exploited commercially (EuroCham 2018). The first hydropower plant (460 KW) was built on Yeni River in Mogok, Myanmar in 1898 (IFC 2018). Since the 1970s, hydropower has become the main source of electric power generation (IFC 2018), contributing about 60% of the total electricity produced in the country (ERIA 2020a).

Myanmar has four main rivers with several smaller rivers and streams suitable for large and small-scale electricity generation. The total estimated hydropower potential is estimated at 100,000 MW (ADB 2016), with multiple locations, that can generate over 48,000 MW, which have already been proposed or identified (ERIA 2020a, p49; Tun 2019).

Myanmar has 29 large hydropower plants generating about 3,398 MW, and 32 small-scale stations producing, in the aggregate, about 33 MW (IFC 2018). The 32 small-scale plants are installed in rural irrigation dams and off the national grid (IFC 2018). Additionally, six plants generating 10 MW capacity or greater (1,564 MW) were under construction, and 69 stations, each scheduled to generate 10 MW or more (43,848 MW) were planned (ERIA 2020a, p48). Subject to all of these projects being successfully executed, prior to February 2021 Myanmar was projected to have built sufficient energy-generating capacity for its population and businesses, as well as for export (ERIA 2020a).

Table 7. Power Plants in Myanmar

Projects	No of Plants	Capacity (MW)
Existing (<10MW)	29	3,398
Existing (>10MW)	32	33
Under construction	6	1,564
Proposed/identified	69	43,848
Total	**136**	**48,843**

Source: ERIA 2020a, p35; IFC 2018, p22

Nevertheless, even if hydro-power stations are successfully built and operated, due to the seasonal shortages of water, these stations' generating capacity drops off in the summer (March-May), resulting in an unreliable power supply (ERIA 2020a).

Prior to 2011, private companies directly proposed and negotiated hydro-energy generation projects with the government, based on studies conducted by the developer specific to the location and type of project (IFC 2018). Currently, there are 22 state-owned hydro projects and 7 more stations privately-owned (IFC 2018). Today, most construction projects approved by the MIC are designed, built and managed by the private sector (ERIA 2020a). Most foreign investors in Myanmar's hydropower industry are Chinese companies (EuroCham 2018). JV agreements allow companies to build and operate plants for up to 40 years before transferring them to the government (EuroCham 2018). Myanmar plans to increase its electricity generation through hydro power by about 38% (8,896 MW) by 2030 (Myanmar National Energy Policy 2014).

3.6 Solar

Myanmar has an estimated solar energy potential of about 52,000 terawatt-hours per year (EuroCham 2018), one of the highest in the world because of its favorable insolation condition, with the maximum potential in the central dry zones of Myanmar (EuroCham 2020). Myanmar has used solar for power generation since 2008 (Khaing 2012 cited in Tun 2019). Small-scale solar projects have been implemented with the support of international organizations, such as the IFC, primarily in rural areas, as were several private projects. Nevertheless, large-scale solar projects are yet to be fully developed (ERIA 2020a).

The first large-scale solar project (220 MW, an investment worth over 300 million in 836-acre solar farm), of Green Earth Power (Thailand), was launched in the Minbu Solar Power Plant in 2019 and the project will take four years to complete (Bangkok Post 2018). There is also another proposed large investment project, worth USD 480 million, of an American company, Covalt Energy, with an installed capacity of 300 MW in the Mandalay region (ERIA 2020a).

Myanmar plans to increase the capacity of renewable energy to 2,000 MW (9%) by 2030. As solar power is intermittent, it needs to be backed up for a sustainable supply of energy. While solar energy has a high favorability due to its abundant supply in Myanmar and its general friendliness to the environment, the major concern for its introduction is its initial high investment costs (ERIA 2020a). ERIA (2020) calculates the levelized cost of energy (LCOE) of solar power in Myanmar at USD 0.140/kWh, lower than that of wind power plants.

3.7 Wind

Even though Myanmar has promising wind energy potential, estimated at over 4,000 MW, mostly in Shan, Chin and Rakhine states (EuroCham 2018), very few projects have been proposed, so far. Several small-scale wind power plants have been implemented, however, contracts for several large-scale wind power projects were signed between the Union government and private companies prior to February 2021 (ERIA 2020a). For instance, in 2014, a large-scale wind power project agreement was executed by the Ministry of Electric Power and Gunkul Engineering Public Company Limited of Thailand and China Three Gorges Corporation. Subsequently, an agreement was signed by a local company Zeya & Associates with a Danish company, Vestas, to construct a wind power plant with an installed capacity of 30MW in the Mon State (ERIA 2020a). An agreement was also signed between China's Three Gorges Corporation and MoEE to develop a 30MW wind energy power plant in Chaung Thar, Ayeyarwaddy Region (Myanmar Times March 2019). However, none of the projects have been completed, so far.

According to the National Renewable Energy Laboratory, ERIA (2020a) calculated the levelized cost of energy (LCOE) of wind power in Myanmar as USD 0.158/kWh which is the highest amongst all power sources.

Table 8. Planned Wind Energy Projects in Myanmar

Region	No of Plants	Capacity (MW)
Rakhine	10	1,484
Chin	10	1,472
Ayeyarwady	6	478
Yangon	2	274
Total	**28**	**3,708**

Source: EuroCham 2018, p19

3.8 Biomass

Biomass, such as firewood, charcoal, rice husk and other plant waste, is one of the major energy sources for households in the rural area (EuroCham 2020). The first biofuel gasification power plant with 0.5 MW installed capacity was constructed in Nay Pyi Taw and subsequently, another plant with an installed capacity of 1.8 MW can be found in Myaung Mya, Ayeyarwady Region (EuroCham 2020). In 2017, biomass covered 48% of the total primary energy supply, higher than oil (29%), natural gas (16%) and hydropower (5%) (ERIA 2020a).

While biomass is an essential source of energy for households for its cheap prices and accessibility, the use of charcoal and firewood have raised serious concerns over deforestation, as well as people’s health due to air pollution (ERIA 2020a). Prior to February 2021, the Myanmar government had initiated substantial efforts to reduce the use of biomass in households and provide alternative energy sources (ERIA 2020a).

3.9 Geothermal and Tidal Energy

Even though Myanmar has huge potential in geothermal and tidal energy, both sub-sectors are in their infancy. Myanmar has more than 93 potential locations which could be commercially explored for producing geothermal energy (Tun 2019). The government had a plan to build a geothermal energy plant with an installed capacity of 200 MW in the western part of the country (Richter 2016).

Myanmar has a coastline of over 2,800 kilometers which could be used to produce tidal energy. The total tidal energy potential is estimated at about 1,150 MW (MONREC 2018 cited in Tun 2019). At this stage, however, electricity generation from either geothermal or tidal energy is at a research state (Tun 2019).

CHAPTER FOUR
ENERGY SECURITY IN MYANMAR

4.1 Introduction

Man-made energy, by nature, has two facets – having it thrives the wellbeing of humanity while lacking it or generating it irresponsibly has negative impacts on our wellbeing as well as on our environment. The energy sector in Myanmar has been in a critical condition because of this natural condition of energy generation and/or utilization, as is the case in many developing countries.

Sustainability is dealing sensibly with tradeoffs – maximizing the desired outcome while risking what a country can afford to pay reciprocally. When addressing sustainability in the energy sector in Myanmar, the first and most important fact is to address the energy security of the country - whether all citizens and businesses have sufficient energy to consume. In other words, any attempts to make the energy sustainable would be in vain so long as parts of the country or population still lack access to energy. Therefore, generating and supplying sufficient and reliable energy for all is crucial to addressing sustainability in the energy sector.

A moral policy question, however, arises whether Myanmar should produce sufficient energy by any means, so that its domestic demand is fully met, or should Myanmar prioritize renewable energy only which, in its current circumstances, cannot generate sufficient energy for its population and industry. Consequently, the goal of the 100% electrification plan will be slowed down. This question is particularly relevant to a country like Myanmar that has the option of both generating renewable and non-renewable energy. The most favorable answer, without a doubt, would be to generate sufficient energy for the whole country from renewable sources at a competitive cost to the non-renewable energy-generating alternatives. This choice, however, has been a challenge in practice, not only for Myanmar but also for other developing countries, due to many factors including limitations of finance, technology, and knowhow etc. (Myanmar National Energy Policy 2014). The study of Rao and colleague (2017) shows that electrification can be prioritized by a less-developed-country’s government only when such country achieves a certain development stage. In Myanmar we say, “One can mediate/do merits only when his stomach is full," thus, a country can focus on providing energy when it accumulates certain wealth and resources.

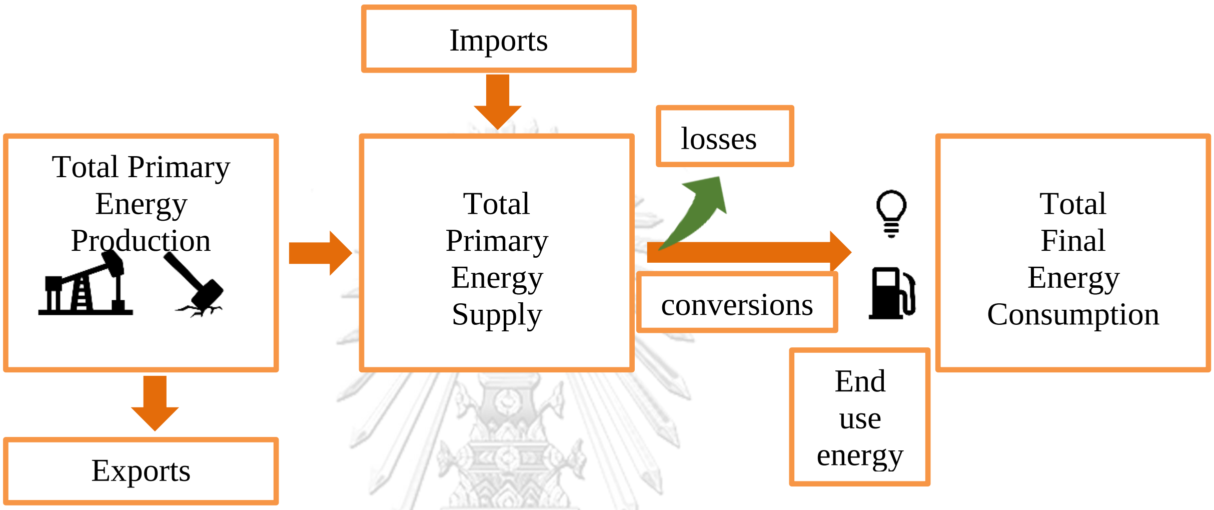
Studying energy security in a country that has one of the highest levels of energy poverty in the world (Vakulchuk et. al 2017) is rather ironical. This study attempts to highlight whether energy security in Myanmar has been either increased or decreased during the two last Union governments: that of President Thein Sein, followed by that of the NLD. Energy security can be studied in various ways, such as studying the level of energy generation a country possesses or accumulates, including from imports, its energy reserves, the estimate lifespan of the energy resources, the quality of the energy supply and transmission/distribution, or even the perception of the population on whether it feels that it has sufficient energy supply to consume.

Myanmar's energy security, from natural reserves availability and generation and transmission of sufficient energy to the users (Yao et. al 2014), is studied in this paper in a number of different perspectives, including analyzing the energy supply (total primary energy supply), then looking at demand/consumption (total final energy consumption), and finally reviewing the balance between electricity production and consumption. It should be noted that, as not all energy resources, such as coal, hydropower, natural gas or oil are not relevant to the general population in many cases, the most relevant form of energy (i.e. electricity) is studied separately in the next chapter.

A country's macro-energy flow can be illustrated as outlined in the figure below. There are three main components: total primary energy production (TPEP); total primary energy supply (TPES) and total final energy consumption (TFEC). The total primary energy production is defined as the country's energy generation from all sources. The total primary energy supply is defined as the sum of all primary energy sources, including imports, but without energy exports (Hanania et. al 2020). The total final energy consumption (TFEC) is defined as the energy used by the final consumers and excludes what is used by the energy sector itself, including but not limited to, deliveries, transformation, distribution loss etc. (EuroStat 2018).

To investigate the energy security of Myanmar, this paper mainly observes the total primary energy supply (TPES) and total final energy consumption (TFEC). In order to evaluate the macro data of energy supply and demand, all energy sources that are different in nature, such as gas, fuel, coal, biomass, electricity etc., are converted into one single, uniform unit of measurement to present an apples-to-apples comparison. Although there are various measurements available, this study uses "tons of oil equivalent" or "toe".

Figure 7. Energy Flow in a Country



Source: Hanania, J. Donev, Jason. (2020)

4.2 Total Primary Energy Supply (TPES)

Myanmar's total primary energy production had a rapid growth between 2000 and 2007, with an overall increase of about 2.4 times in volume (ADB 2016). During that period, biomass took the biggest share of the total energy production - around 46%, natural gas grew by 43%, and hydro, oil and coal covered the remaining 11% (ADB 2016).

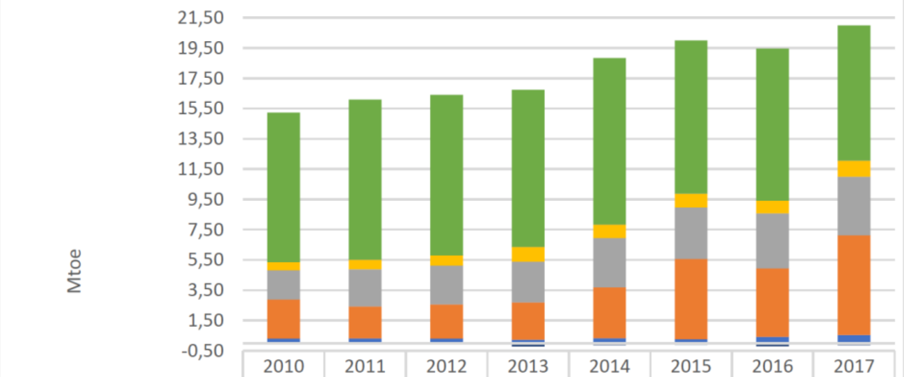
Myanmar was able to increase its total primary energy supply (TPES) at an average annual rate of about 4.6% per year from 2010 to 2017 – reaching 21 Mtoe in 2017 (ERIA 2020b), from a variety of energy sources, such as hydropower, coal, natural gas and oil supply, except for biomass (N.B. the following total primary energy supply data is obtained from ERIA's reports of 2019, 2020a, 2020b).

Among the energy sources, oil supply was the fastest growing with an average annual growth rate of about 15%. The share of the oil supply increased from 17% in

2010 to 32% in 2017 due to the growth of the transportation sector, industrial demand, and increased LPG consumption by the residential and commercial sectors. During the same period, hydropower-generated energy supply increased at an average rate of 10.7% per year, while remaining the largest source of electricity generation in Myanmar. The share of other power sources, such as wind and solar, were negligible (0.004%) during this period. Natural gas supply also grew from about 2 Mtoe 2010 to almost 4 Mtoe in 2017, due to increased operation of gas-fired plants with an average growth rate of 10.5% per year. Coal supply also increased with an average annual growth rate of 8% between 2010 and 2017. Biomass supplied energy decreased during this period from 10 Mtoe in 2010 to 9 Mtoe in 2017. Additionally, its share in the total energy supply decreased from 65% in 2010 to 43% in 2017. However, biomass remained the major energy-generated supply in the country in 2017.

While this positive growth trend resulted in more energy supply for domestic use, one has to determine whether the final consumption rate increased as well in Myanmar in order to fully assess the country's energy security.

Figure 8. Total Primary Energy Supply (2010 – 2017)



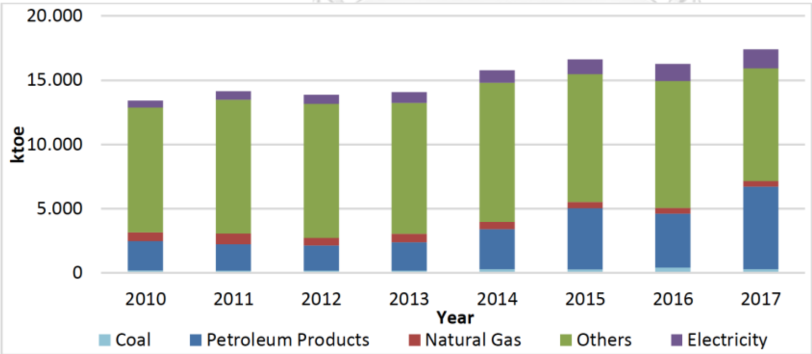
	2010	2011	2012	2013	2014	2015	2016	2017
Electricity	0,00	0,00	0,00	-0,22	-0,13	-0,11	-0,20	-0,12
Biomass	9,87	10,56	10,60	10,37	11,00	10,12	10,04	8,91
Geothermal, Solar etc.	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Hydro	0,53	0,65	0,67	0,97	0,89	0,91	0,84	1,08
Gas	1,93	2,46	2,58	2,69	3,25	3,40	3,63	3,88
Oil	2,57	2,10	2,25	2,47	3,37	5,29	4,53	6,58
Coal	0,31	0,32	0,31	0,23	0,33	0,27	0,41	0,54

Source: ERIA (2020b), p4

4.3 Total Final Energy Consumption (TFEC)

According to ERIA (2018), (2019) and (2020) reports Myanmar's TFEC between 2010 and 2017 was in the form of coal, petroleum products, natural gas, electricity, biomass, and others, increasing from 14 Mtoe in 2010 to 17 Mtoe in 2017, at an average annual growth rate of about 3.8%. Biomass was still the most consumed energy in 2017, but with a declining share, from 72.4% in 2010 to 50.5% in 2017, due to the increased electrification rate and increasing household use of liquefied petroleum gas (LPG). Both the consumption of petroleum products and electricity experienced fast growth in the same period. The average annual growth rate of petroleum product consumption was about 15.8% per year, while for electricity the annual consumption growth rate was about 15.2% per year. During this period, the Thein Sein government relaxed the used car import rules, which became the main driver for the petroleum product consumption growth. The total number of vehicles increased at a rate of 8.2% between 2016 and 2017. Coal consumption also increased at an average rate of 6.9% per year over the same period.

Figure 9. Total Final Energy Consumption by Fuel Type

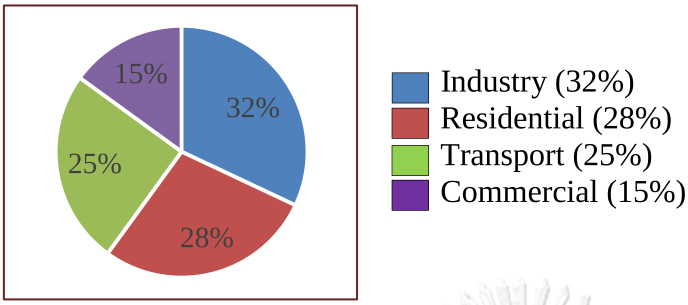


Source: ERIA (2018, p2)

In terms of segmentation of energy consumption by sector, industry consumed the highest amount at about 32% of total consumption and grew at an average rate of 3.1% per year. The second highest consuming sector was residential at about 28%, with an average annual growth rate of 0.3% per year, followed by the transport sector at 25%, being the fastest growing consumption at an average rate of 17.2% per year.

Finally, the commercial sector consumed about 15% of the total final energy, while it decreased its consumption at an average rate of 0.9% per year.

Figure 10. Total Final Energy Consumption by Sectors Between 2010-2017



Source: ERIA 2018; 2020b

4.4 Evaluating Energy Security

As discussed, energy security can be studied in various ways. The IAEA et. al (2005) discusses and compares the study of energy sustainability as a medical checkup of a patient. The patient's health can be evaluated in a number of ways: body temperature, weight-to-height ratio, blood pressure, pulse rate, cholesterol level, etc., to mention just a few. Conclusions can be drawn from how these numbers change over time, whether a patient's health is improving or deteriorating. The same "open-ended" analysis method can be applied, in general, to the energy sustainability of a country and energy security, in particular. How sustainable or how secure should the energy of a country be? Even though there is no universally agreed level of sustainability or security of a country's energy, as in the health example, we could and should aim for a progressively improved trend in the graph to evaluate a country's success. Energy sustainability cannot be achieved without having energy security: being able to possess the necessary natural resources to produce the energy, and then efficiently and reliably supply sufficient energy to the entire population, as well consistently support the country's business activities.

This study attempts to evaluate the total primary energy generation, transmission, distribution and consumption of Myanmar a macro-level to determine the trend of energy security in Myanmar. Over the years, the total primary energy supply of the country has been lower than the total primary energy generation due to its massive exports (ADB 2016) – primarily gas exports which accounts for over 70%

of its total gas production (Ministry of Electricity and Energy 2017). Myanmar also exports electricity (which was equivalent to 13% of the total electricity produced between 2013-2016) to China since 2013 via cross-border exports in areas without connection to the national grid (ERIA 2020a). ERIA reports of 2018, 2019 and 2020b show a notable increase in all the energy supply-chain between 2011 and 2017: the primary energy generation, transmission, distribution, and consumption as follows:

Table 9. Comparison of TPES and TFEC between 2011 and 2017

Total Primary Energy Supply		Total Final Energy Consumption	
2011	**2017**	**2011**	**2017**
16 Mtoe	21 Mtoe	14 Mtoe	17 Mtoe
Average rate: 4.6% growth		**Average rate:** 3.8% growth	

Mtoe = million tons of oil equivalent
Source: ERIA (2018); ERIA (2019); ERIA (2020b)

As the economy of Myanmar grew over the past ten years, there was a direct demand increase for energy in the country, as its energy consumption also increased. Not only that the existing population's demand for energy is increasing, but the country needs to address the demand of its increase in population, higher wealth level, as well as additional integration into the national grid of those marginalized segments of the population without past access. The average population growth between 2010 and 2017 was about 0.8% per year (ERIA 2019). However, the overall total primary energy supply was also increased to meet the increased demand, even though the production of crude oil has declined at about an average rate of 7% per year between 2010 and 2017 (ERIA 2018). In general, all chains of energy generation, transmission, distribution and consumption increased at a relatively similar growth rate of about 4%. The energy dependency (ratio between the total energy import and the total energy supply) of Myanmar had increased from 7% in 2010 to 19% in 2017 – almost reaching 3-folds (ERIA 2020a). Myanmar is dependent on energy imports, mostly oil imports and a small share of coal (ERIA 2020a). One of the main concerns, however, is the continuous huge share of biomass in the consumption. Even though it has decreased over time, it still contributed over 50% of the total consumption in 2017 (ERIA 2020a). Biomass fills the gap in the country's energy security by fulfilling the energy needs of rural households, mostly unconnected to the national grid, which cause massive implications on deforestation, environment, and health issues of the locals. According to ERIA (2020b), the energy security of Myanmar on a national level had not been deteriorating even though the energy dependency had increased 3 times in the last decade. Myanmar would certainly need to find ways to become less dependent on energy imports in order to have sustainable energy generation in the country.

At a national policy level, however, the energy security of the country has been under-addressed. Possessing substantial raw energy reserves: 105 million barrels of oil, 6.58 trillion cubic feet of gas, 542.56 million metric tons of coal, over 100,000 MW in hydropower, 52,000 Terawatt-hours in solar, 4,000 MW in wind, and over 1,150 MW in tidal energy (estimated in ERIA 2020a; EuroCham 2018), Myanmar needs not be concerned for lack of raw energy resources. It is only a matter of how much or whether it can extract and transform raw materials into final products. Without a doubt, though, successive governments have lacked the will, know-how and/or tools to transform these energy resources into commodities. Professor Ricardo Hausmann of the Harvard Kennedy School of Government (2015) argues that the secret of economic wealth of nations is the “collective productivity” of the country, i.e., the ability to transform raw materials into a variety of products. According to him, the more products countries can produce by transforming raw materials into finished goods or services, the richer they are. In his example, in a scrabble game, the richer countries are those that can spell more words with their seven letters. Unfortunately, Myanmar lacks this ability, especially to enhance energy security for domestic consumption.

Myanmar’s energy policy, through February 2021, addressed energy security through several laws and policies (NEP, the Foreign Investment Law, the Company Act, to mention a few) by providing more regulatory facilitations encouraging private sector participation in a heavily state controlled environment. Some examples of these incentives include the opportunity for foreign companies to invest in local companies, up to a maximum 35% ownership share, without changing the ownership nationality of the company, longer tax holidays, protection of foreign companies with MIC permits from nationalization, creating a more inclusive and transparent tender processes, etc. After the 2005 failure of the nationwide Jatropha curcas plant (*Kyetsuu*) to produce biofuel, a project of the previous military government, successive governments have shifted their focus on extensive generation of energy from existing natural sources.

Nevertheless, current energy policies still fall short of adequately addressing the country's energy security on two grounds. First, due to an export-oriented policy which requires exporting a large quantity of energy resources (particularly natural gas and electricity) before fulfilling the basic needs of its population, industry and agriculture, the country is left bereft of the resources needed to fulfill its power needs. For instance, between 2011-16, Myanmar exported about 70% of its explored natural gas and about 13% of its generated electricity to neighboring countries, while half of its population does not even have access to reliable modern electricity. While it may be impossible to revoke the existing energy export contracts (for instance, contracts of export to China and Thailand are valid for about 30 years after the signing date, with possible extensions), Myanmar can at least halt extending them and signing new energy exploration and generation contracts exclusively fulfilling its domestic demand.

The second concern is the failure to address sectoral mismanagement, which is the inability to fully take an advantage of the energy potential of the country while improving the energy generation sector's management. For example, Myanmar's crude oil refineries are operating at an estimated 33% to 57% of capacity, according to the ADB 2012 report, and not building any new refineries. As a result, Myanmar has to import over 90% of petroleum products to feed its domestic demand for oil, gasoline and diesel. Currently, Myanmar imports about 600,000 tonnes of oil per month, mainly from Singapore, which in turn buys it from other oil exporting countries (Myanmar Times April 2018). Thus, Myanmar pays an estimated price premium of USD 12 million per month (Myanmar Times Feb 2018). Furthermore, the challenge for Myanmar is the lack of sufficient oil storage infrastructure. In order to buy oil directly from oil exporting countries, Myanmar needs to increase its existing storage capacity by a factor of five (Myanmar Times Feb 2018). as of 2018, there were over 2,000 fuel stations and 50 fuel distribution companies in Myanmar (Global New Light 2018), many of which do not have a fuel storage capacity. With the existing storage infrastructure, Myanmar oil importers can only store 20,000 tonnes of oil per shipment (Myanmar Times Feb 2018). Due to this fuel import dependency, and other factors (e.g., international fuel prices, USD/Kyat exchange rates, etc.), fuel prices in Myanmar fluctuate widely (Global New Light of Myanmar May 2018). Nevertheless, as of May 2018, Myanmar ranked second, after Malaysia, with the lowest fuel prices among ASEAN countries (Global Petrol Prices 2018).

Over the past ten years under civilian governments, these energy resources exports (i.e., natural gas and electricity) boosted the foreign currency revenues of the country, which, in turn, was arguably used for the country's public healthcare, education, poverty alleviation, and the overall development of the country, thus benefiting the general population. For example, Myanmar's 2018 revenue alone from natural gas exports exceeded USD 3 billion, which represented half of the national export revenue (Myanmar Times March 2018). The question, though, is how many people actually benefited from this government revenue, thus being able to improve their living standards, education, healthcare, etc., to mention just a few. Moreover, what would have been the national benefit in increased investment and development if these exported resources were transformed into electricity for domestic consumption? To put it another way, how many trees would the country been able to save if modern electricity would have been available for cooking and general chores in rural households? One can conclude that looking just at the dollar value (i.e., the export revenues) does not reflect the big picture of development of the country and that of its population. Given the estimated quantity of energy reserves the country possesses, both in the renewable and non-renewable forms, Myanmar has the potential to produce and supply sufficient energy for its domestic consumption, now and in the future, as well as export the surplus to earn foreign currency. Thus, Myanmar needs to adopt urgent policy changes to strengthen its energy security. To achieve sustainable development of the country, Myanmar today needs to focus on providing sufficient energy for domestic consumption as energy underpins the economy, society, and the safety of the environment. As a result, this thesis argues that sustainability is going beyond a cost and benefit analysis - converting resources and tradeoffs into dollar value.

CHAPTER FIVE
ELECTRIFICATION IN MYANMAR

5.1 Electricity Generation and Access in Myanmar

Electricity is by far the most relevant and useful energy around the world compared to coal, natural gas, and oil in a modern society. In economic terms, electricity is considered a commodity, even though it has many distinctive features (Lesourd 2004; Kropyvnytskyy 2020). Electricity is supplied immediately with zero delivery time, unlike other typical commodities such as rice or oil (Kropyvnytskyy 2020). For instance, as soon as a consumer turns the switch on, the bulb is lit. The fact that electricity is not usually stored on a national level directly makes it require instant generation and consumption (Lesourd 2004). Both electricity demand and supply, as well as the electric generation capacity, particularly from renewable sources, are seasonal (Kropyvnytskyy 2020). For instance, hydropower plants may produce less energy in summer when there is less rainfall, and from the demand perspective, people and industry may use air-conditioners more during the summer. Moreover, electricity is not, so far, directly traded on the global markets, unlike other commodities such as oil, gas and coal, but traded locally in certain regions, such as North America or the EU (Lesourd 2004). Additionally, there can also be loss in the transmission and distribution of electricity, especially if the transmission and/or distribution lines are at some distance from the generating capacity, are older or if the transmission is disrupted (Kropyvnytskyy 2020).

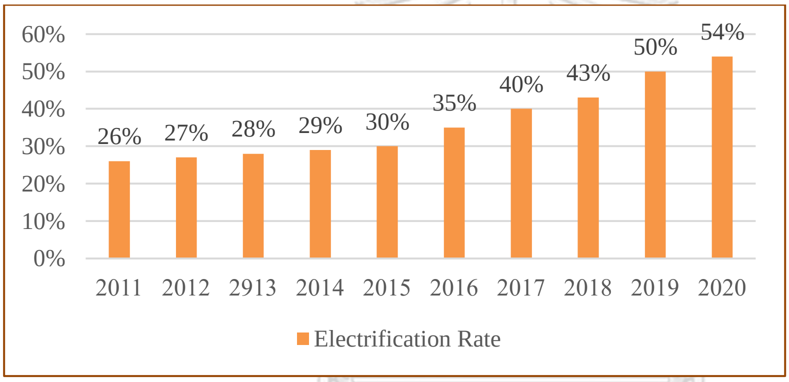
Electricity can be measured in two different forms: demand and consumption. Electricity demand is measured in kilowatts (KW) and represents the rate at which electricity is consumed; the consumption, on the other hand, is measured in kilowatt-hours (KWh) and represents the amount of electricity that is consumed over a certain period of time (BuildingOS 2017). For example, to power a computer, it may require 20W from the grid, however, the energy consumption will range based on the number of hours it is used. If the computer is on for ten hours, the consumption of the computer is 200Wh whereas the demand of the computer remains the same at 20W.

Myanmar has been generating its own electricity, without any imports, mainly from hydropower, followed by gas, and a small amount from coal and diesel. Even though there is some solar generation in some rural households and very few businesses, the overall combined capacity is negligible. Myanmar does not have nuclear energy as of now, nor a plan for the future. Electricity is supplied through the national grid which is solely overseen by MOEE. Where the national grid does not reach, electricity is supplied by small diesel generators and mini hydro power plants (NEP 2014, p12). Currently, there are 83 power-generation plants: 62 hydropower, 20 gas-fired power and 1 coal-fired (OBG 2020; Asia Foundation 2019). Four new LNG power plants and several new projects are under construction and discussion since 2019, but due to COVID-19 and the ongoing coup, information on whether those plants will be operating any time soon is not available at this time. As far as security and sustainability in the energy sector is concerned, using a mix of energy sources is positive as one type of energy source can compensate for the weakness of others. For example, solar functions with a higher effectiveness in the summer when hydro power capacity declines.

The per capita energy consumption in Myanmar has been among the lowest in ASEAN (Asia Foundation 2019), reflecting low per capita incomes and electrification rate (ADB 2012). In 2011 (ADB 2012, p23), the total electricity installed capacity of the country was only 3,361MW and it was able to provide electricity to 26% of the population from hydropower plants (2,520MW, or 75%), gas-fired plants (715MW or 21%) and a coal-fired plant (120MW, or 4%). By 2019, however, the total electric installed capacity was increased to about 5,642 MW, and 50% of the population had access to electricity. Of that total generation capacity, about 58% comes from hydropower (3,255MW), 38% from natural gas (2,175MW), and about 2% each from coal (120MW) and diesel (92MW), respectively (MoEE 2019; EuroCham 2020). As of today, 54% of the population has access to electricity on the national grid (Harrison et. al 2020). The rest of the population either has no access to modern electricity or is dependent upon firewood, unreliable diesel-fired micro-grids, or small solar systems (MONREC et. al 2016).

Myanmar was able to double its electricity supply - from 26% in 2011 to 54% in 2020, and the per capita consumption of electricity increased from 111KWh per year in 2010 to 235KWh per year in 2016 (Asia Foundation 2019). However, the share of renewable energy has increased to 29% only, mainly of hydropower. Even though there has been a measurable increase in use of solar power in the rural households and a few businesses, the amount is still negligible overall. Purely from a national electrification rate standpoint, Myanmar overachieved in 2019 its goals listed in the National Electrification Plan (NEP), increasing energy security in the country, even though the country has a long way to go to fulfill its 100% electrification goal by 2030. The NEP targeted 47% electrification rate by 2019, whereas the 50% actual rate exceeded the target. One major threat to the country's energy security is the underperformance of existing power plants. OBG (2020) estimates the actual effective generating capacity is only between 2,900 – 3,100 MW, regardless of the seasons, whereas the installed capacity is over 5,642 MW.

Figure 11. Proportion of Population with Access to Electricity 2011-2020



Source: IEA (2018)

The chart below shows the generative capacity comparison of each Myanmar energy source between 2010 to 2016. It should be noted that the diesel electricity supply is the off-grid choice in some rural areas which are not reached by the national grid.

Table 10. Electricity Supply by Source 2010 - 2016 (GWh)

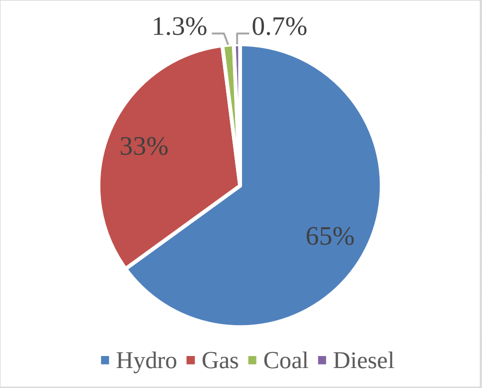
Year	Hydro	Diesel	Coal	Gas	Total
2010	6,189	33	391	2,012	8,625
2011	7,544	38	312	2,556	10,450
2012	7,766	51	265	2,883	10,965
2013	8,778	61	136	3,227	12,202
2014	8,829	65	70	5,193	14,157
2015	9,399	55	-	6,518	15,972

2016	9,744	61	10	8,053	17,868
Total	58,249	364	1184	30,442	90,239

Source: MoEE (2018) cited in ERIA (2019, p19)

On average, between 2011 and 2016, 65% of electricity was generated from hydropower, 33% from gas, 1.3% from coal and 0.7% from diesel (ERIA 2019). As hydro power is green and renewable, even though large hydro power plants can deteriorate the ecosystem and the livelihood of the people living along the river, its share of electricity-generation is a relatively positive source. On the other hand, though, from an energy security and sustainability standpoint, the production of hydropower declines in the summer, when hydropower functions 30% less in the summer (Dodge 2017), which causes an increasing supply shortage in the country just when the electricity consumption is higher (NEP 2014).

Figure 12. Average Energy Generation in Percentage by Sources (2010-2016)



Source: author calculation based on ERIA (2019)

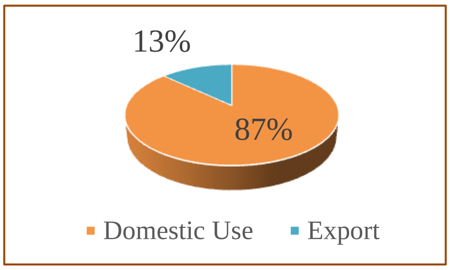
In addition to its substantial electric power generating shortages, Myanmar exports a substantial portion of the domestic-produced electricity to China. A country with the poorest electricity access and consumption rates in Asia is exporting a substantial percentage of its electricity to a country that has 100% electrification rate. Myanmar started exporting electricity to China since 2013, mostly from hydro power. This export accounts for about 13% of the domestic-produced electricity between 2013 and 2016. The export to China is carried out without connection to the national grid.

Table 11. Electricity Export (GWh)

Year	Export
2013	2,532
2014	1,463
2015	1,239
2016	2,381
Total	7,616

Source: ERIA (2019)

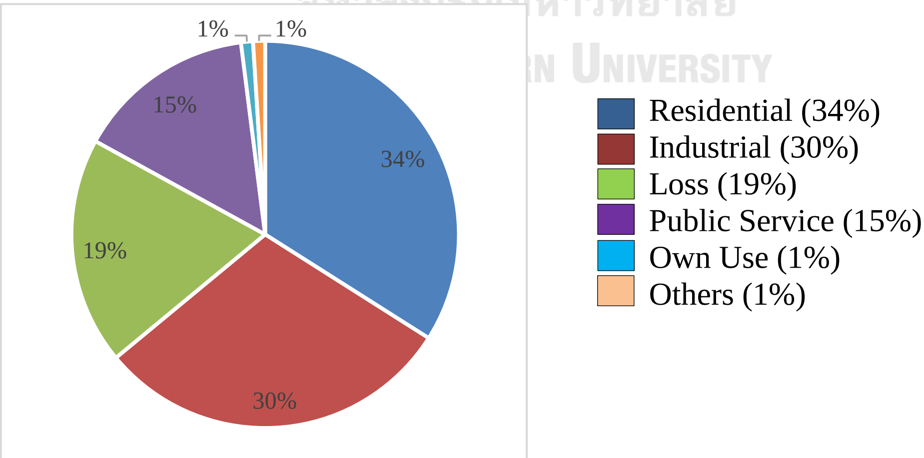
Figure 13. Export vs Domestic Consumption (2013 – 2016)



Source: author's calculation based on ERIA (2019)

In terms of electricity consumption, between 2010 and 2016, the residential sector consumed the highest percentage, at about 34%, of the generated total, followed by the industrial sector (30%), and public services (15%). One of the most alarming factors, though, is that there has been a major loss of electricity in the transmission and distribution which, on average, amounts to about 19%. Even though a certain loss is common for any electricity transmission and distribution, especially over long distances, 19% loss is excessive, due largely to old and relatively low voltage lines, outdated equipment, and stolen power (Rabin 2015). To be noted, 70% of the national grid's transmission lines are over 75 years old (Rabin 2015).

Figure 14. Average Electricity Consumption by Final Users (2010-2016)



Source: author's calculation based on ERIA (2019)

5.2 Overview of Electrification Policy and Governance

The energy sector management at the union level in Myanmar is multifaceted - involving many entities within the government body. While the Ministry of Electricity and Energy (MOEE) is the focal point of energy management and supervision of the whole country, the DRD of the Ministry of Agriculture, Livestock and Irrigation oversees the rural off-grid electrification; Ministry of Education administers renewable energy; and the Ministry of Industry masterminds the energy efficiency. While the bright side of the sector being governed by many ministries is that it supposedly comes with more expertise and experience, the downside is that it creates inconsistent policy and red tape which affects the overall development of the country.

Within the MOEE's sole jurisdiction, energy governance is a top-down bureaucratic approach including, but not limited to, the granting of licenses for projects over 30MW, electricity generation, transmission, distribution and trading electricity across national borders, subject to the approval of the union government, with limited power conferred to the state and regional governments (Asia Foundation 2019). State and regional governments are permitted to approve projects that are less than 30MW that are not planned to connect to the national grid, and/or investments of less than USD 5 million. There is, however, for project over 30MW, state/region governments and MOEE need to negotiate because the states' residents and environment are affected by the project (Asia Foundation 2019). This power sharing structure and unwritten rules for negotiation between the states/regions and the MOEE impact several matters: causing opaque investment procedures for investors, hindering investors with multiple projects in different states and regions as they have to deal with different rules in each state and/or region, and affecting the energy policy of each state and/or region (Asia Foundation 2019).

While many newer energy projects are either fully owned by private companies or a joint venture between the private companies and the state enterprises, the majority of hydropower plants are Union-owned through its Ministry of Energy and Electricity (MOEE). Over 60% of Myanmar's overall installed electric-generation capacity is owned by MOEE (Dodge 2017), and the rest is owned by private companies, mainly Chinese firms.

In the last decade, Myanmar has been actively promoting its energy sector, in particular the electrification effort throughout the country. Myanmar currently has three energy plans at the Union level (Dodge 2017), while six states and regions have adopted energy laws for their respective jurisdiction (Asia Foundation 2019). The three energy plans include National Electrification Plan (NEP), developed by the World Bank and UN in 2014; the Myanmar Energy Master Plan, introduced by the National Energy Management Committee of Myanmar's Union government and sponsored by ADB in 2015; and National Electricity Master Plan, developed by JICA in 2014. However, there has been criticism of these separate plans as inconsistent with each other, except for the general goal of 100% electrification by 2030 (Asia Foundation 2019, p15). Therefore, having multiple unaligned roadmaps creates unclear direction in Myanmar's journey towards sustainability in the energy sector. Prior to February 2021, energy projects were permitted on a project-by-project basis, without a requirement or procedure to follow a strategic plan or roadmap, including the policy framework on public notification, community involvement, and investment risk such as land rights, exchange rates, the structuring of PPAs and concession agreements (Asia Foundation 2019, p43). Harrison and Arnold (2020) also stress the importance of having a clear roadmap and leadership in achieving Myanmar's ultimate goal of 100% electrification.

In order to achieve 100% household electrification in Myanmar, NEP (2014) estimates the need to produce a total of 23,594MW by 2030, which means Myanmar has to quadruple its current installed capacity. By 2030, NEP (2014) envisions that 38% will be sourced from hydropower (8,896MW), 33% from coal (7,940MW), 20% from natural gas (4,758), and 9% from other renewable sources (2,000MW).

5.3 Challenges for Electricity Security

As it is obvious from the previous discussion, electricity security is today non-existent in Myanmar. A country that is able to install only about one fourth of the estimate required electricity for the whole population has no secured electricity at all. Moreover, even the 54% of population that today has access to electricity still experiences blackouts and low voltage on a regular basis. To fill-in the electricity supply gap, the rural population still heavily relies on biomass (firewood, charcoal etc.) for cooking and heating, causing serious deforestation, as well as experiencing a deterioration of its health. The general population is not the only one affected, as businesses suffer from the insufficient and unreliable electricity supply, causing disruption in their production and/or services, as well as higher expenses for additional power supply such as diesel generators.

Several organizations, including the government of Myanmar and its three major sponsors in electrification, the World Bank, ADB and JICA, have undertaken research and studies on how to improve the country's electricity security. While lack of development investment in and financing of the energy sector has been addressed, we must also investigate the existing problems within the energy supply chain. This paper argues that the existing electricity security is threatened by several major issues: outdated power plants, transmission and distribution loss, seasonal impacts on the power plants, electricity tariffs, electricity export, and the power relation structure between the state/region and Union government.

Ensuring the efficient operation of existing power plants is as important as securing financing and the construction of new power plants, and respective transmission and distribution lines in order to supply electricity to the portion of the population that currently lacks such access. The OBG (2020) estimates that current power plants are functioning at less than half of their respective installed capacity (between 2,900 – 3,100 MW vs 5,642 MW) regardless of seasons.

Second, minimizing electricity loss in the supply chain needs to be addressed. While it may be impossible to achieve zero-loss in the transmission and distribution of electricity, an average loss of 19% of the total production per year is alarming. Rabin (2015) points out that such loss is due to old and low voltage power lines, outdated equipment, and stolen power. The US Energy Information Administration (EIA 2021) estimates that the current transmission and distribution losses in the US are about 5% to show a comparative case. As previously mentioned, 70% of Myanmar's national power grid lines over 75 years old (Rabin 2015).

Being able to generate more than half of the total electricity from renewable hydro sources makes the electricity sector in Myanmar relatively healthy. The majority of hydropower generating stations that are not connected to the national grid are small and relatively less damaging for the environment. The downside to hydropower, as previously mentioned, is that these power plants function less efficiently (by up to 30%, on the average) during the summer when electricity demand is at its highest, in addition to potential offline stops caused by malfunctioning (Dodge 2017). Therefore, Myanmar needs to further diversify its energy sources. Currently, the main electricity sources are hydro (65%) and gas (33%). A small amount is produced from coal (less than 2%) and diesel (less than 1%). Having massive potential in solar, wind and tidal energy in additional to hydro and other non-renewable sources, the country has a huge potential to grow its renewable energy supply. Myanmar's success depends on how quickly, and broadly it can take advantage of this existing potential. For example, the existing one coal power plant is criticized for its environmental impact and human rights abuses during the plant's construction. However, this plant has been operating since 2005 during the military regime and abandoning it now would not make sense when half of the population is starving for electricity.

Since 2013 electricity from hydro power plants has been exported to China. This energy export before meeting domestic demand is highly threating to the country's energy security. As a reminder, this export accounts about 13% of Myanmar generated electricity between 2013 and 2016. Furthermore, the existing energy tariff structure and environmental consideration within the sector, which are discussed in the next chapters, are also significant factors impacting energy security in the country.

CHAPTER SIX
ENVIRONMENTAL POLICY INTEGRATION IN ENERGY

6.1 Introduction

Between 1999 and 2018, Myanmar has suffered major losses due to extreme weather-related events, which were ranked second in the world (OECD 2020; MCCS 2019). Moreover, various reports have found no likelihood of improvement in the immediate future if no major remedial action is taken. For a country that is heavily dependent on agriculture, which accounts for 30% of the country's GDP and involves more than 70% of the population directly or indirectly rely on forest resources (MCCS 2019), the combined effect of environmental degradation and climate change have enormously impacted the country. The carbon footprint of the country's development activities, as well as the irresponsible, excessive consumption of natural resources over a long period of time, have compounded the detrimental effects of climate change, and in return, climate change is threatening the people's livelihood. Furthermore, such actions hinder the country's ability to have sustainable development, in effect creating a vicious circle. For example, between 1995 and 2014, Myanmar experienced 41 extreme weather events which resulted in an average annual rate of 7,146 deaths, a negative impact on GDP with an average decrease of 0.74% per year, the destruction of thousands of public housing and individual homes, and negatively impacting millions of people and their livelihood (MCCS 2019, p20). Cyclone Mala alone destroyed in 2006 10% of Myanmar's reserved forest (MCCS 2019, p59). Between 1990 and 2017, the forest coverage area shrank, in part due to irresponsible deforestation, as well as due to natural events, from 60% to 44% of the country's territory, impacting hundreds of endemic plant and wildlife species (OECD 2020). Moreover, the average temperature has risen about 0.35 degree Celsius per decade in the lower land regions (MCCS 2019).

Climate change is considered one of the global public commons having cross-border externalities. Both of its origin and impact are global i.e., it has occurred due to the collective actions of all nations and mankind, and it also affects everyone although the impact is not the same for everyone causing deeper suffering for the marginalized society and underdeveloped nations, such as Myanmar. Therefore, when addressing climate change, the solution should be ideally adopted both at the individual and global level (collaboration among states), without any free riding. As much as a country is required to be cautious about its industrial carbon emission and ecological footprint, raising the public awareness for responsible consumption and activities also greatly matters. Irrespective of how advanced our technology and science improve, human beings have and will always be dependent upon the natural environment for their survival. It is impossible to consume without affecting the environment, as even "green consumption is still consumption" (Robbins et. al 2014). At a minimum, human beings breathe out, without a choice, carbon dioxide in the atmosphere, which impacts the ozone layer. Therefore, human beings do not have a choice but depend upon the environment for their survival. The big question, however, is where to draw the line between "survival consumption" and "luxury consumption," especially in a highly materialistic society.

In a modern society the increased use of energy, both at the individual and global levels, has become a necessity for the economy, as well as the functionality of the society. Myanmar's energy demand has increased over the years, and it is further forecasted to grow at an annual average rate at about 7% over the next 30-year period to 2050 (MONREC et. al 2016; ERIA 2019). To be able to prepare for broader and consistent future development, how should Myanmar secure the energy demand of today and be ready for the future growing demand while tackling our shared climate change issues?

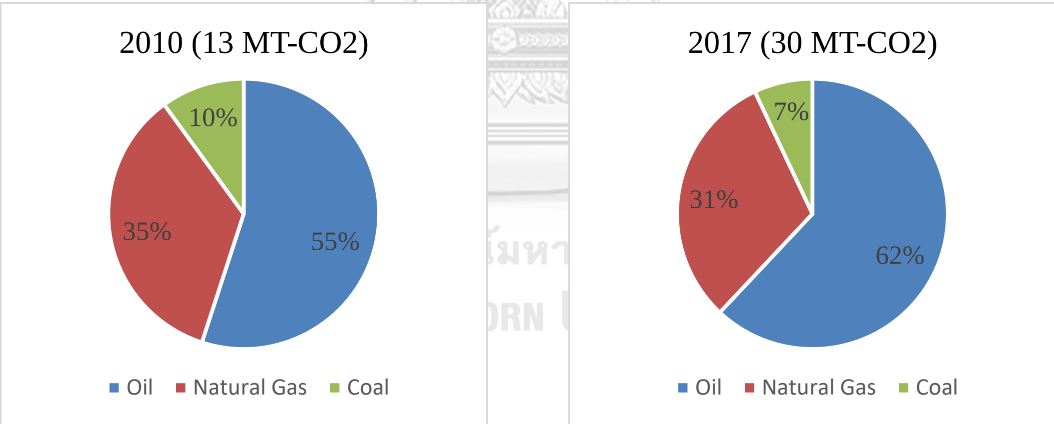
Environmental protection and climate change considerations have rather been quite a new topic in the political agenda in Myanmar. From traditional governance of the environment and wildlife conservation through antique colonial era laws (Aung 2002), Myanmar has taken a bolder move recently in implementing domestic laws which have adopted policies for environment protection and climate change mitigation, as well as entering several international treaties.

Unlike several other countries, Myanmar fortunately has a golden chance to leapfrog from fossil fuel-based energy and embrace the renewable energy era (MONREC et. al 2016). This opportunity may lead Myanmar to a higher moral ground – a duty to serve the existing population but also a moral responsibility to reserve resources for its future generations. Therefore, how Myanmar articulates and integrates environmental and climate change policies in the energy sector today will greatly determine the sustainability of the sector in the future. This chapter will critically review the Myanmar government's initiatives to address climate change and environmental degradation in relation to the energy sector.

6.2 CO2 Emission Between 2010 and 2016

One way to measure the impact of government's development measures on climate change and energy security is to study the CO2 emissions of the country (Yao et. al 2014; ERIA 2020a). Between 2010 and 2017, Myanmar's CO2 emissions have increased at an average annual rate of 13%, reaching around 30 million ton-CO2 in 2017 (ERIA 2020a). Combustion from oil constitutes the major source of CO2 emissions in Myanmar, while the balance is made up of burning natural gas and coal (ERIA 2020a). Unfortunately, additional GHG emissions' contribution comes from deforestation and forest fires (MCCS 2019).

Figure 15. CO2 Emissions by Fuel Type



Source: ERIA 2020a, p7

6.3 Policy Measures Addressing Environmental and Climate Change in the Energy Sector

Prior to the early 2010s, Myanmar did not have structured environmental safeguards and promoted green investment. The concept of governing the environment, during those periods, was most noticeable in the ways forests were managed. Under the SLOR military dictatorship regime, the Ministry of

Environmental Conservation and Forestry (MOECAF, currently known as MONREC), had administered the country's forests under colonial laws: the 1902 Forest Act and the 1936 Burma Wildlife Protection Act (Aung 2002). Among the issues concerning these century-old colonial laws were that they were outdated and had been adopted to serve the British interests in the commercial exploitation of forests. To see how the Myanmar's forests were exploited by the British is discussed in detail by Bryant (1993). Therefore, it is not surprising that the forest governance and policy in Myanmar have leaned towards anthropocentric ideology. Newer environmental laws were passed only in the mid-1990s: 1995 Forest Rules (updated in 2019), 1995 Forest Policy, 1995 Community Forest Instruction (amended in 2016, repealed in 2019), 2012 Environmental Conservation Law (amended in 2018), 2014 Environmental Conservation Rules, 2012 Vacant, Fallow and Virgin Lands Management Law (amended in 2018), 2014 Nationwide Ban on Raw Timber Exports, 2016 ten-year ban on logging in Bago Yoma Region, 2018 Conservation of Biodiversity and Protected Areas Law, 2019 Community Forestry Instructions and Forest Master Plan 2001-2031.

The responsibilities of MOECAF included, but were not limited to, the formulation of the country's environmental policy, as well as the protection, conservation and planting of trees. Furthermore, it controlled and regulated the commercial exploitation of the forests in order to generate national revenues, including harvesting, milling, and marketing of forest products (Aung 2002). In Myanmar, the definition of the term "forest" includes both natural and "man-made" forests, or monoculture plantations such as rubber, pine, or teak plantations. The political debate of whether to promote monoculture plantation raises an argument that planted forests lack the ability to host biodiverse habitats, and it can be easily, commercially taken advantage of to the overall detriment of the environment. For instance, a company can clear up a large area of forests to grow a certain type of trees for commercial exploitation, as in the case of palm oil plantations in Indonesia, Brazil and elsewhere. The Myanmar government started the planting of teak forests in 1856, and large-scale forestry plantation in 1980 (Aung 2002).

Although Myanmar, during the military regime, joined several international agreements as early as 1993 (Vienna Convention for the Protection of the Ozone

Layer, Montreal Protocol on Substances that Deplete the Ozone Layer, and, more recently, 15 other global and regional agreements), it was not until 2012 that the government started to build national environmental safeguards to promote green investment in energy and other sectors (OECD 2020). The new Environmental Conservation Law 2012 and the Environmental Conservation Rules 2014 introduced modern environmental management, including launching the establishment of specific environmental quality standards for the country, such as the use of environmental impact assessments (EIAs) and initial environmental examination to screen development activities which are technically supported by JICA, ADB and World Bank (OECD 2020).

Table 12. Environmental Review Requirements for Different Types of Power Plants

Type of Power Plant	IEE Required	EIA Required
Hydropower plants	If ≥ 1 MW	If ≥ 15 MW
Natural gas or biogas power plants	If ≥ 15 MW	If ≥ 50 MW
Waste-to-energy power plants	If ≥ 50 MW	At discretion of ministry
Geothermal power plants	If ≥ 5 MW	If ≥ 50 MW
Combined cycle power plants (gas/thermal)	If ≥ 5 MW	If ≥ 50 MW
Other thermal power plants	If ≥ 5 MW	If ≥ 50 MW
Wind power plants	If ≥ 1 MW	If ≥ 15 MW
Solar power plants	If ≥ 50 MW	At discretion of ministry

Source: Asia Foundation (2019), p17

The National Environment Plan 2018-2030 promotes integration of environmental issues across sectors, the Myanmar Sustainable Development Plan (MSDP) 2018-2030 aims for sustainable development through environment and climate protection, the Myanmar Climate Change Strategy (MCCS) 2018-2030 promotes climate protection actions, whereas the Nationally Determined Contribution outlines, at least on paper, mitigation and adaptation priority actions (OECD 2020) in compliance with twelve environmental related laws. These policies, which are targeted to be accomplished by 2030, summarize the national strategic vision reflecting the UN SDGs, climate change, and several ASEAN agendas.

MSDP is underpinned by three Pillars (Peace & Stability; Prosperity & Partnership; People & Planet), with 5 Goals, 28 Strategies and 251 Action Plans. All the five targets of UN SDG 7 are interestingly enshrined in MSDP – referring to SDG (7.2) six times, SDG (7.3) and (7.b) twice each, and SDG (7.a) once. The SDG (7.1 - universal access to electrification) is slightly differently articulated as "Ensuring access to affordable, sustainable energy for rural populations and vulnerable groups" (MSDP 2018, p57). The dual purposes of these strategies and plans are, on the one hand, to prioritize access to electricity and, generally, to natural resources by the most marginalized and underprivileged groups, as well as to ensure that those who already have access to electricity have reliable and consistent supply, which, today, is not the case in Myanmar. The common main issue of SDG 7 and MSDP is their vague integration of environmental protection within the energy sector. The goals and indicators of both plans heavily focus on universal access to electricity, increased share of renewable energy, energy efficiency, energy intensity, infrastructure, technology, etc., which are all crucial to the sustainability of the sector. Nevertheless, these policies fail far short of providing a guideline or framework for environmentally friendly generation of energy. As discussed in chapter 5, renewable energy is highly favored, compared to non-renewable sources, due to its mitigated impact on the environment. However, just increasing the share of renewable energy in the country's energy mix does not guarantee an environmentally safe generation of energy.

MCCS has identified six different areas which may mitigate the impact of climate change on the country, namely: a) agriculture, fisheries, livestock; b) natural resources and the environment; c) energy, transport, and industry; d) cities and human settlements; e) health, disaster risk management and social protection; and f) education, science, and technology. Although MCCS lays out 18 expected results for these chosen areas, with a total of 45 indicators, it acknowledges that the indicators are rather general and may measure, at best, a degree of progress.

> "(Indicators are meant) … to orient the country in what it can measure to assess – rather than quantify – the degree of progress as the quantification of progress may not be realistic over 13 years and at this level of complexity" (MCCS 2019, p116).

Energy, along with transport and industrial systems, is addressed in the MCCS as Priority Sector No. 3. The expected results from the progress to be achieved are: energy security and efficiency, efficient and low-carbon transport technology, and productive and low-carbon industrial systems. While the MCCS promotes the large picture of climate change, it insufficiently defines the necessary reforms needed in light of the climate change concern for this sector. For instance, "energy security" is inadequately defined as being able to increase the use of renewable sources, and energy efficiency. Sourcing energy from renewable sources is, by its very nature, a better alternative without GHG emissions. Increasing the share of renewable sources in the energy-generation mix, however, will not necessarily result in increased energy security, primarily because renewable sources do not guarantee sustainability. Thus, additional measures need to consistently be taken for environmental and social safety reasons, as Priority Sector No. 3 and the MCCS overall do not adopt clear targets, or timing, to be achieved in relation to the environment (OECD 2020).

Over the past ten years, the government has taken multiple steps towards adopting several new strategies and actions to achieve sustainability with the support and partnership of international organizations. These policies, however, prioritize energy security and generation for domestic consumption, setting environmental considerations as an afterthought. For instance, Myanmar's government has designed its policies in order to generate the electricity needed for the existing population and industry, as well as the future growing demand with any available means. Under the current National Electrification Plan (2014), Myanmar targets to generate four times its existing installed capacity with a mixture of 38% hydropower (8,896MW), 33% coal (7,940MW), 20% natural gas (4,758MW), and 9% from renewable sources (2,000MW). While environmentalists are concerned about the increased share of coal from 2% currently, to 33% by 2030, many economists and experts question the feasibility of the mission. In addition to the ambitious goal of 100% electrification rate by 2030, what concerns the critics even further is the national plan to reduce energy consumption 12% by 2020, 16% by 2025, and 20% by 2030, as per MONREC et. al (2019), compared to a 2012 baseline year, as an effort to combat climate change. One of the major concerns in Myanmar's proposed energy projects, to this day, is the social impact – forced eviction, land grabs, resettlement of the local population

(Irrawaddy November 2019). In many cases, the locals are paid insufficient compensation for their farmland and resettlement, not to speak of dislocations of ethnic minorities from ancestral lands on which their families lived for generations. For example, a Chinese company, CNMC Nickel Company, with the help of the Myanmar military took an area of 3,000 acres on which 122 local farmers were reportedly paid less than USD $40 per acre in 2007 (Irrawaddy November 2019).

One has to recognize that energy generation and consumption cannot be realized with zero impact on the environment, irrespective of which generation source is used. Therefore, Myanmar should choose the least environmentally impactful energy generation, transmission and distribution methods which are economically feasible, such as renewable sources. Furthermore, the government should monitor environmental safety along with the generation process at a cost it can afford. The question, once more, is at which level and at what cost can the Myanmar government integrate environmental measures in the energy sector while it is trying to maximize the much-needed energy generation, transmission, and distribution to the general population? If, indeed, consistent, and well-thought-out steps are gradually taken through the existing policies and strategies, improvement can be achieved over time.

A keen observer of Myanmar's journey into environmental protection and policy over the past ten years leads one to believe that Myanmar is still in the early stages of achieving a sustainable, environmentally safe energy policy, and furthermore, its current situation is far short from international standards. Joining the global agenda of fighting climate change, the former two governments have seriously taken their responsibility. The result has been an obvious improvement of environmental protection and green investment in the national agenda from 2011 to 2020. Furthermore, one must also acknowledge the bold environmental reforms, that the country had taken prior to the events of February 2021, which may hinder accelerated development of sustainable energy generation, transmission and distribution, or the achievement of energy security and further may detract investors, foreign and domestic. Even though the ultimate goals are yet far ahead, the baby-steps and improvements that the country was able to make during the past ten years deserve to be recognized.

6.4 Areas for Improvement

As discussed, the environmental consideration in the energy sector in Myanmar is still far short of satisfactory today, although noticeable improvements were made over the past few years. Reports from both academic scholars and international organizations provide sound recommendations in regards to environmental considerations needed in the sector: detailing the need to provide capacity building training, in particular to MONREC staff for EIA evaluation and engineering training for MOEE staff, support the ministry financially and technically, develop energy efficiency frameworks in the commercial and the public sectors, leveraging the new Project Bank: a website that lists all projects available for public-private partnership, promote and incentivize green investment, impose a carbon tax, legalize feed-in tariffs and net metering, decentralize the power structure in the ministry, restructure energy tariff structures, etc. Agreeing with most of these recommendations, except for the imposition of a carbon tax in the present conditions, this study further identifies two major areas of improvement to integrate environmental consideration in the sector: improving the share of renewable sources and an inclusive integration of environmental protection and promotion framework within the energy policy.

As discussed in previous chapters, the country targets, under its National Electrification Plan, to generate only 47% (10,896 MW: 38% from hydro and 9% from other renewable sources) of its required energy from renewable sources by 2030 and yet the majority (53%) is planned to be generated from non-renewable sources, in particular coal (33%) and natural gas (20%). This means that the share of renewable sources will decline from 58% today to 47% by 2030, if the plan works out. This increased target in non-renewable sources is utterly contradicting the energy goals set in MSDP and MCCS, i.e., increasing the share of renewable sources. When hydropower alone can produce four times of what the whole country will need by 2030 and having massive potential in wind, tidal and solar energy, attempting to scale up the non-renewable forms does not appear to be a sound policy.

The prominent and valid counterargument to plan the increased share of renewable sources in the national energy plan has been the fact that the country does not currently have access to financing to develop the sector as it desires, including prioritizing green resources. For example, the NLD government did not seek a sovereign credit rating, thus, the country cannot enter international financial markets. Without considering the current and past political stigma, the unclear regulations and procedures for investment, and very low energy tariff structures (energy tariffs will be further discussed in the next chapter) and the initial high investment costs in renewable energy, alone have imposed abundant challenges for companies to invest in renewable energy generation sources, and in particular, in solar and wind energy. Supposing, however, that the energy tariff structures can be updated, and acceptable regulatory reforms take place in all relevant ministries, Myanmar surely can aim for higher than 47% of renewable sources. For instance, there is a USD 480 million worth of solar investment, proposed by Covalt Energy, sitting in the pipeline for several years. Increasing the share of renewable energy is one of the most desirable means Myanmar can take to mitigate the impact on the environment, including reducing GHGs which will help mitigate climate change.

Second, there needs to be a more integrated environmental consideration within the energy sector itself. Assuming the adoption of all discussed environmental measures and improvements, the current norms which focus only on energy "security" i.e., being able to increase the use of renewable energy, energy efficiency, efficient, resilient and low-carbon transport and industrial systems (highlighted in the MCCS), need to also address the universal access to electricity, clean fuels and technology, enhanced international cooperation in clean research and technology, improved infrastructure and investment (also spotlighted in the MSDP). In a nutshell, these proposed policies which merely echo the need to increase the share of renewable energy, energy efficiency and low-carbon transport and technology need to be reflected in new norms.

As in the case in UN SDGs, the aim to protect and preserve the environment is set as a separate goal from the energy goal (i.e., SDG 7 enshrines energy related goals and SDG 15 targets environment or ecosystem consideration). This paper points out the urgent need to integrate the environment consideration in SDG 7 itself. One might point out that, in order to provide a solution, Myanmar recently introduced EIA procedures to evaluate investments and the use of natural resources in Myanmar. Setting aside the unsatisfactory qualifications of MONREC's staff to evaluate various

EIA reports originated from international investors (an area where capacity building training is recommended), the government's norms need to have minimum targets or acceptable baseline of environmental safety and protection within each proposed energy project.

Reports of the IFC (2018) state that EIAs in Myanmar, which are not generally up to international standards, are conducted after the submission of the feasibility studies to the MOEE. Consequently, they do not contribute to important investment factors, such as project siting, design improvement etc., which would help mitigate negative impacts. One other example of failure which affects the lack of protection of Myanmar's forests is that land is divided into different categories and those categories are governed by different ministries. For instance, vacant and fallow land is overseen by the Ministry of Agriculture and Irrigation whereas mining and "forestry" are governed by the Ministry of Environmental Conservation and Forestry (MONREC). What this implies is that forests that are on vacant and follow land do not have the same protection as in the "forestry" category. In addition to the lack of clear mapping for these different types of land, when an energy project is proposed/planned on the land that is not under the "forestry" areas, the forest protection rules become inapplicable. Integrating environmental considerations within the energy sector itself will have a good chance to prohibit "green grabbing" - where land or natural resources are exploited in the name of climate change. The bigger question is: what is the level of environmental consideration the country can afford in its energy project evaluations, especially in an energy starving society? By inviting environmental and energy experts to an established public consultation, consistent with internationals norms, politicians and policy makers should open up public debates and develop a collectively acceptable decision.

CHAPTER SEVEN
ELECTRICITY TARIFFS

7.1 Electricity Tariff Structures

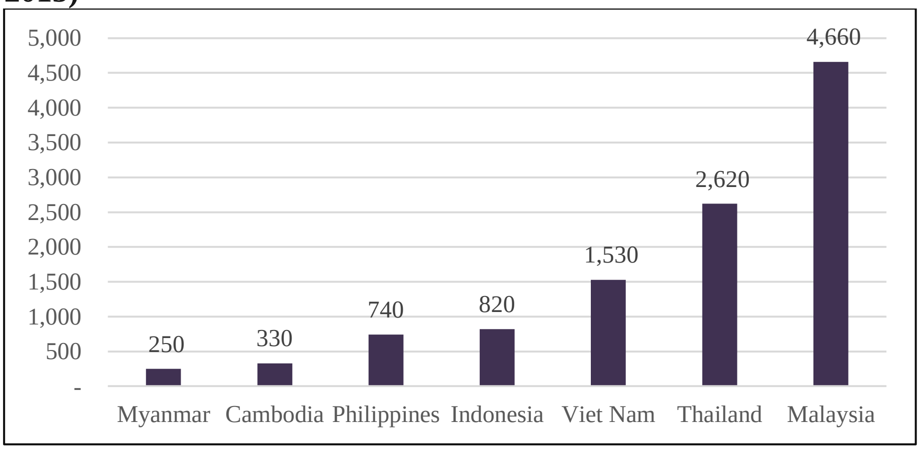
Concerning energy prices, two competing arguments have overwhelmed the public policy discourse in political philosophy. On the one hand, the “equity perspective” or moral responsibility of the government is to provide its citizens with the basic public common goods, such as education, healthcare, police and fire protection services, to mention a few, at minimal cost, if not free. This argument of treating energy as a human fundamental right is mainly based on the need to create equality of opportunity in society by protecting the vulnerable groups from marginalization of access to basic human needs. Therefore, the government, it is argued, is morally responsible to make energy prices affordable, if not free, by either setting affordable minimal prices, or by subsidizing the electric power fees of those who cannot afford them. Energy prices of a country are usually compared with the GDP per capita on a national level to assess the affordability coefficient for the majority of the population. On the other hand, the “business model perspective” (i.e., all expenses of an operation must be covered by its revenue to make the production sustainable) would require that sufficient funds are collected from the electricity users to insure the long-term functionality of the electric system’s generation, transmission and distribution, plus maintenance. Therefore, this latter argument is that energy prices should be calculated based on the total energy cost.

All these different ideas come down to one question – should access to energy be treated as a right? Even though there is no human rights convention or agreement that explicitly spells out energy as a human right, many scholars agree there are moral grounds for seeing energy access as a right (Lofquist 2020). With this notion, whether access to electricity should be proposed as a human right rises when considering the level of dependency our society has on energy today (Lofquist 2020). Provided that this notion is agreed to by everyone, what would a right to electricity be like as a principle? Lofquist (2020) discusses the three possible principles where access to electricity can be treated as a right – contractual right, derived right, and universal human right.

In a society that is deeply rooted in a market economy, sustainability in the energy sector unfortunately comes with a price. This paper argues that the energy affordability to the general population is as important as the ability to cover the generation, transmission, distribution and maintenance expenses and outsourcing the required capital funding of the sector's resilience and long-lasting establishment, especially in a developing country like Myanmar. To provide sufficient energy for all and mitigate climate change, the world requires massive amount of capital investments. Sustainable Energy for All (n.d.) reports that a minimum investment of USD 45 billion is required annually by 2030 to achieve universal energy access around the world. Just for building the energy supply infrastructure which would stabilize the atmospheric CO2 concentration, the world needs accumulative investment of USD 53 trillion (Grigoroudis et. al 2019). As for Myanmar, the World Bank calculates that a total of USD 30 billion is needed (Asia Foundation 2019, p12), which is almost half of the GDP of the country in 2019, in order to achieve universal electrification of the country.

Having only 54% of the population currently connected to the national grid, Myanmar's electricity generation and consumption stands at the bottom among ASEAN members. With the lowest generation capacity and tariff, the per capita consumption in Myanmar is 2.5 times less than Lao PDR, 9 times less than Thailand, 28 times less than Singapore and 4 times less than the average ASEAN countries (Asia Foundation 2019, p52).

Figure 16. Electricity Consumption in Selected ASEAN Countries (KWh/capita, 2015)



Source: Alvarez et. al (2018, p67)

Furthermore, the electricity tariffs in Myanmar are the lowest in ASEAN (OBG 2020, p110). However, this is not necessarily because the electricity generation costs are cheaper in Myanmar. The government has been heavily subsidizing the industry, under several administrations, in order to fill the gap between the generation and distribution costs and the collected tariffs. The subsidization of energy tariff jumped from USD 378 million in 2017/2018 FY to USD 488 million in 2018/2019 FY (OBG 2020), and it is expected to increase to as much as one percent of GDP in the next few years (Myanmar Times June 2019). This foreshadows a building crisis, in that, with the current tariff structure, the government will have to bear even a greater burden of financial losses when the whole country is electrified.

Although the affordability of electric tariffs to the public was always a great concern, tariff hikes have been introduced twice between 2010 and 2020 – one initiated by the Thein Sein government in 2014 and the later by the NLD-led government in July 2019 as an effort to narrow down the tariff losses. The table below shows the tariff details between 2011 and the present. Even though the latest tariffs increased at a rate about 73% from the 2014 rates for an average consumer, the rise is not yet sufficient to cover the real generation costs (OBG 2020; Myanmar Times June 2019). Currently, Myanmar government's generation and transmission costs are 89 kyats ($0.05) per unit for hydro-generated electric power, and 178 kyats ($0.1) per unit from natural gas (Myanmar Times June 2019), whereas the baseline tariffs are 35 kyats ($0.02) for residential and 125 kyats ($0.07) for commercial use, respectively. The first tariff hike in 2014 was able to increase revenues by about USD 272 million annually (Irrawaddy March 2014), while the 2019 tariff hike resulted in an even bigger income for the government. However, even after these tariff hikes, the electricity tariffs in Myanmar remain among the lowest in the ASEAN and is still far short of the real generation, transmission, distribution and maintenance costs (OBG 2020). In addition to the energy tariff, another related financial burden for the citizens is that individual households are responsible for the grid connection costs, which are in the range of USD 300 to USD 400 per household (Myanmar Times November 2020).

Table 13. Electricity Tariff Rates Between 2011 and 2021

Types of Consumers	Current Rates		2014 Rates		2011 Rates	
	Units	Ks	Units	Ks	Units	Ks
Residential - Residence - Religious residence	1 to 30	35	1 to 100	35	1	40
	31 to 50	50				
	51 to 75	70				
	76 to 100	90				
	101 to 150	110	101 to 200	40		
	151 to 200	120				
	>201	125	>201	50		
Commercial - Companies - Embassies - Industry - International organizations	1 to 500	125	1 to 500	75	1	75
	501 to 5,000	135	501 to 10,000	100		
	5,001 to 10,000	145				
	10,001 to 20,000	155	10,001 to 50,000	125		
	20,001 to 50,000	165				
	50,001 to 100,000	175	50,001 to 200,000	150		
	>100,001	180				

1 kyat = USD 1,600 (exchange rate of 20 June 2021)
Source: Myanmar Times (June 2019) & Dapice (2012, p10)

7.2 The Implications of Insufficiently Low Energy Tariffs & Recommendations

As discussed, the low electricity tariffs in Myanmar are undoubtfully a major hindrance in the progressive development of the sector (Dapice 2012). First, it puts a great strain on the government's budget and its investment strategic plan. For a government whose total 2020 budget was about USD 25 billion (Myanmar Times August 2020), this annual average subsidy of about USD 300 million constitutes a large part of its deficit of about 5% GDP, and drags the country into an unsustainable and unclear future. As previously discussed, the biggest obstacle to the 100% electrification goal by 2030 is not the lack of energy-generating resources, but rather the lack of finances, along with the lack of technology, know-how, and structural issues, as well as diverging political goals. Multinational agencies, such as the World Bank, ADB, IFC, etc. have provided some low-interest loans in order for the government to pursue this goal, however, the provided amounts are insignificant compared to the needs of the country. Additionally, energy tariffs are not the only area the government should channel its attention towards. The requirement for households to shoulder the grid connection costs make it harder for the success of universal electrification by 2030. Again, the grid connection fee per household ranges between USD 300 to USD 400 (Myanmar Times November 2020).

These circumstances put the government into the position of seeking both local and international private investors in the development of this sector. As the government controls the sole electricity distribution network in the nation, any energy generated by investors must be sold to the government unless it is exported to neighboring countries. Therefore, the sale of electricity to consumers at a subsidized price creates another obstacle to reaching power purchase agreements between the government and investors. As a result, many investors, foreign and domestic, shy away from investing in the Myanmar energy sector, the result of which is that half of the population, as well as industry and farmers do not have access to modern energy. Currently, the government is buying electricity from existing investors in the country at higher rates than the electric power tariffs collected from the users. As an example, the details of existing PPAs negotiated on a case-by-case basis between the government and the investors (DFDL 2019) are not publicly available, yet the Myanmar Times (June 2020) quoted the energy ministry's deputy permanent secretary that the government signed a five-year PPA with Chinese company VPower for USD$0.12 per unit, which is a substantially higher price than the electric power tariffs ($0.02 per unit for residential and $0.07 per unit for commercial).

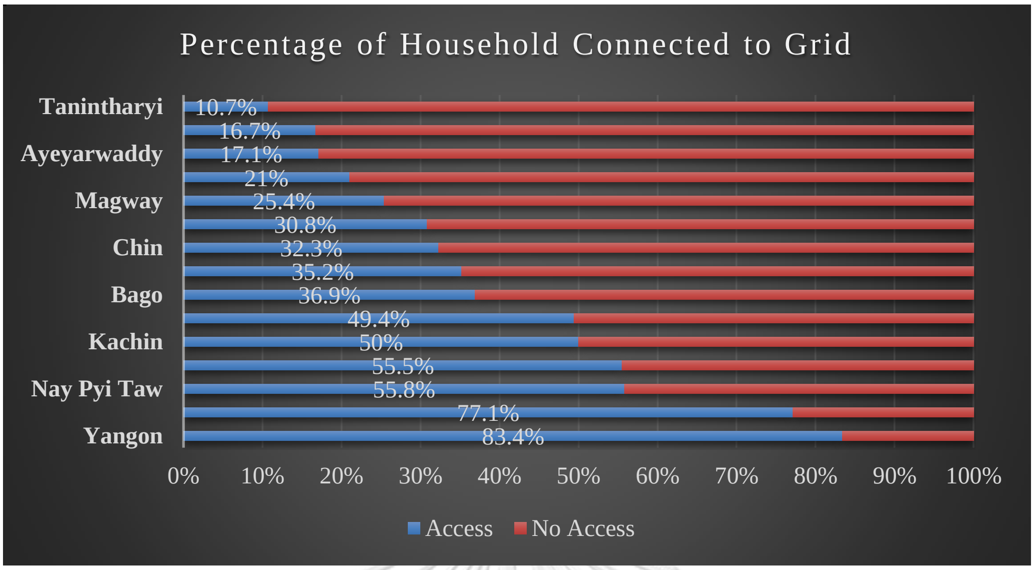
These circumstances further lead one to question the universal electrification proposals. Currently, the tariff subsidization covers only half of the population (54% have access to electricity, so far). Even if the government is supposedly able to provide electricity to the whole country, under the current tariff structure the required subsidization will be massive. As discussed, these subsidies can reach about 1% of the GDP in the near future. Another complexity is that the PPAs with international investors were concluded in United States dollars, however, the government's collection of tariffs is in Myanmar kyats, thus there is a currency exchange risk (DFDL 2019). Although each PPA term vary greatly, it normally is between 20 to 30 years (DFDL 2019).

When addressing prices or money in a market economy, their ramifications do occur not only in the economy but also in the social arena. When electricity tariffs are set at the "lowest rates" possible for the "average consumer", they are not necessarily the ones benefiting from it (Myanmar Times May 2018). It is the middle- and above-income groups which, in effect, are being subsidized by the lower income consumers.

Even with the lower tariffs of 2014, it was calculated that a consumer of 50 KWh per month receives a subsidy of about 3,500 kyats (USD$2), while a consumption of 500KWh per month gets 30,000 kyats (USD$19) (Myanmar Times May 2018).

Second, due to extremely limited energy resources, our moral compass requires ensuring an equal access opportunity for every citizen to access resources in order to create sustainable development across the entire country, and in particular in the underdeveloped minority areas. Specifically, Myanmar has eight major ethnic groups with more than 135 sub-ethnic groups, thus the distribution of energy resources means more than attempting to create equality of opportunity. It also means creating justice, peace, and harmony. As discussed, Myanmar does not generate sufficient electricity, or has the necessary infrastructure for the whole country to be supplied. Therefore, for now, it has no other option but to share the existing available resources. The question is whether the current distribution of energy resources is fair and, furthermore, whether it creates an equal opportunity for everyone to thrive. Unfortunately, the distribution of such basic needs as electricity is highly uneven throughout the country, leading into a continuous marginalization of certain ethnic and/or social groups and regions throughout history (Harrison et. al 2020). For instance, Yangon Region has electrification rates of 83%, whereas Taninthargyi is barely over 10%. Furthermore, nine states and regions out of 14, which include the poorest areas in the country (ADB 2018), have less than 40% of their households connected to the national grid (Harrison et. al 2020; Asia Foundation 2019).

Figure 17. Electrification Rate in States and Regions



Source: Asia Foundation (2019, p20)

Some will argue that, under the utilitarian ideology of the "cost-benefit" analysis, investing in more populated bigger cities such as Yangon and Mandalay returns "the greatest amount of good for the greatest number." Second, further extending the same analysis to the "business-oriented development," electricity is theoretically "needed more" in the commercial areas. Therefore, by prioritizing to the commercial areas, the country has a higher chance to achieve economic growth which can lead faster to sustainable development.

While these counterarguments have some validity, they fail to address the complexity of the social and economic structure of the country. In many cases, in Myanmar, the currently marginalized areas, from an energy distribution standpoint, are the ones with abundant natural resources, and not only energy. Therefore, exploiting these areas' natural resources to "feed" the more commercial areas is not morally a fair arrangement, nor, for that matter, a rational economic investment argument. For instance, the Union government has been earning massive revenues from the Shwe Gas Project in Rakhine State. How does Rakhine State benefit from its resources today? A 180 MW gas-fired plant was built in the state and only 16% of its population has today access to electricity and the state still stands as one of the poorest states in Myanmar. Even though all states and regions contribute towards the

Union government's revenues, perhaps unevenly, there needs to be a bolder national policy that better recognizes their respective contribution by sharing resources and appreciation. Moreover, when considering the individual taxpayer's contribution, residents of rural areas pay the same tax rates as the rest of the country. Therefore, when electricity is not available to them, but only available to the "other" half of the population with a subsidized tariff covered by the collective union budget, it can be further concluded that the underserved half of the taxpayers are not only denied a level playing field, but also partially bearing the costs of supplying electricity to those who enjoy its availability.

Moreover, this discrimination creates a structural marginalization of a large part of the population in resource-sharing. In any case, electricity accessibility is not the only government resource that is not distributed equitably in today's Myanmar. Many other public resources, such as healthcare, education etc., have been under-provided in these marginalized areas throughout history. For example, even if the government were to allocate some computers to be distributed among schools throughout the country, such computers will only be sent to schools with electricity. IT products and services, such as the internet, online classes etc., will be available under the same reasoning of "the greatest amount of good for the greatest number of people."

Considering the continuous energy dilemma in Myanmar, this study argues that a sound solution may be to use the middle approach between the two previously stated arguments - the "equity perspective" and the "business model perspective." It is not financially healthy to spend almost 0.5 percent of GDP of the country every year for energy subsidization. Simultaneously, citizens who are at the bottom of the social structure need progressive assistance and consideration so that they may have a fair opportunity of access to public commons. Therefore, the government should ideally set a price of energy based on the actual production rates, but at the same time, adopt a social welfare program for the grassroot community in order to target inclusive development. By doing so, the much-needed financing and private sector investment will be more possible in the country while still extending subsidies to the needy.

CHAPTER EIGHT
CONCLUSION

The concept of sustainability was inserted in the UN platform more than three decades ago with the stated goal of protection of the environment. As attractive and catchy as the term "sustainability" may be, the implication of the concept of environmental consideration in our economy, to put it in the simplest terms, is to produce less and consume less, and eventually "grow" less. In other words, sustainability is not about inventing new growth means, but rather growing within the limits of nature, as pointed out by Adams (2006). Therefore, to a certain extent, the notion of sustainability is a "degrowth" policy, as argued by Friedman (1962).

Sustainability is debatably one of the concepts that international development studies cannot avoid. As discussed in the literature review, scholars define and approach the sustainability concept in numerous ways (Qizilbash 1998): from mere environmental protection (moderate ecocentrism), addressing the whole life support system (extreme ecocentrism), to responsible capitalist approach (anthropocentrism), and anything in between. Among these contested ideologies of sustainability, this study proposes a "moderate approach" – an ideology leaning towards anthropocentrism, but with a moderate environmental consideration. Although this study does not see the ecosystem of the world as intrinsically worthful as the extreme ecocentrism does, it concurrently attempts to point out that human beings cannot live independent of the environment. Therefore, it is crucial to preserve the environment for the benefit of human welfare.

As energy production, distribution and consumption is one of the major threats to climate change, addressing sustainability in the energy sector is critical. However, studying sustainability at the energy sector level is not to conclude that energy is a sectoral issue, as discussed in the literature review. So, what does sustainability mean for the energy sector? As discussed, current studies show that sustainability in the energy sector is investigated in multiple ways. Among them, arguably one of the best-known studies is Goal 7 of Sustainable Development Goals (SDG 7). The unintended weaknesses of SDG7 are multiple, specifically, its "key business themes" are limited only to "universal access to clean and affordable electricity; renewable energy, and investments in infrastructure and environment" (UN Global Compact 2015). Although these themes are highly critical to sustainable development, putting the responsibility on the government for a commodity to be “affordable” is a rather debatable proposition in a market economy, setting aside the nuance of what price is “affordable” to the general public. Provision of energy tariff subsidies is a different matter. However, government-enforced price policies in a market economy contradicts free market values. Second, as this paper discussed at length, increasing the share of renewable energy does not guarantee sustainability. There needs to be a more comprehensive mechanism to govern the energy production, particularly in protecting the environment.

Compared to the existing studies on the subject matter, the significance and uniqueness but not necessarily superiority of this study is how it articulates sustainability in the energy sector for Myanmar. As all nations are not, at any one time, on the same level of development, sustainability in the energy sector should be tailor-made for each country’s unique circumstances. While wealthy countries are attempting to increase the share of renewable energy and introduce a decarbonized economy, developing countries, such as Myanmar, are struggling, among other challenges, to find a solution to the universal electrification of the country. It is, therefore, impossible to develop a common baseline or ranking for the energy sector’s sustainability that can equally apply to all nations at any one time. In fact, studying sustainability is like an individual’s medical check-up (IAEA et. al 2005). While a doctor observing a person’s body temperature, weight-height ratio, blood pressure, etc. over a period of time can determine the health of the patient, the same data cannot be used to evaluate the health of another patient.

When studying sustainability in Myanmar’s energy sector, this thesis explores more than just renewable energy and identifies major hindrances, as well as areas for improvement in the sector. Although renewable energy sources are more favorably compared to non-renewable sources, they do not by themselves guarantee sustainability. From a normative policy analysis approach, this thesis extensively investigates the sustainability of the sector by critically observing three broad areas: energy security, progressive consideration of the environment, and the financial health of the energy sector between 2011 and 2020.

Energy security is studied on two different levels in this paper: the overall energy security at a macro level, and, separately, electricity security. On the macro level, the soaring total energy consumption was matched by the increase in the overall primary energy generation, with a respective average growth rate of about 4%. The energy import dependency, on the other hand, jumped up from 7% in 2010 to 19% in 2017. Second, even though the share of biomass in the total energy generation has decreased substantially during the same period, it remained the main energy contributor, supplying 50% of the total consumption in 2017. On the other hand, the growth of access to electricity has been accelerating at a rate of 4%, which was higher than the goal set for 2020 by the National Electrification Plan (NEP). In a nutshell, Myanmar was able to generate and import energy to improve its energy security level, primarily at the macro-level. Nevertheless, the push for universal electrification needs a major acceleration, especially to strengthen electricity security and achieve 100% electrification by 2030, despite the current moderate growth in generation and supply. Major recommendations for strengthening energy security include, but are not limited to, the eradication of export-oriented policies before meeting domestic demand, focus on further production of energy, upgrading underperforming power plants and transmission infrastructure, and adopting sound sector management, including the decentralization of governance in the sector.

Over the last ten years, under civilian governments, Myanmar has made several bold moves in addressing the environmental impact of such growth at the national level. Emerging purely from the "traditional" norms of environmental governance before the early 2010s, two successive civilian Union governments were able to build national environmental safeguards in order to encourage "green" investment, launch the establishment of specific environmental quality standards as well as procedures to screen projects through IEE and/or EIAs. Additionally, the Union government was able to join seventeen international environmental agreements and establish two prominent strategies to enshrine the UN sustainable development goals: Myanmar Sustainable Development Plan 2018-2030 and Myanmar Climate Change Strategy 2018-2030, along with the adoption of twelve new or amended environment-related laws. Considering this short period of time (i.e., ten years), the political turmoil and tension between conservative and liberal ideologies as to whether to relax or strengthen market and/or trade restrictions, the adopted environmental initiatives and related legislation were undeniably noticeable. Moreover, several controversial energy projects were also cancelled or postponed by the Union government in support of public concerns towards the environment and their potential social impact (e.g., the postponement of the Myitsone dam project, or the cancellation of a coal power plant project in Kayin State). Despite these and other positive achievements, this thesis also notes that the country's energy policy is understandably leaning towards an anthropocentric ideology (i.e., prioritizing the population's needs for energy over environmental conservation and protection). This thesis identifies two major areas for progressive conversation and protection of the environment in the energy sector: a) increasing the targeted share of renewable generation sources in the national electricity plan and b) adoption and integration of targeted environmental considerations within the energy sector.

The third pillar of this study (i.e., finding the right structure for energy tariffs) has created, over time, an enormous dilemma: how much can the basic electricity consumer of an underdeveloped country, which has one of the lowest per-capita GDP in the region, can afford to pay for his/her electricity? And how much and how long can the government afford to subsidize the cost of electricity generation, transmission, distribution and maintenance, in addition to securing the capital funds to develop the network, in an economy whose GDP is about USD 75 billion and an annual government budget of about USD 25 billion? Although the energy tariffs have been increased twice within the study period of 2011-2020, the real cost of electricity production and distribution is far higher than the present tariff rates, resulting in an unhealthy financial condition for the sector's sustainability. This thesis extensively discusses the underlying social, economic, and political implications of this dilemma, especially as the half of the population which has access to electricity is receiving massively subsidized fees (e.g. over USD 400 million in 2020), while the other half has no access. As sustainability comes at a price, this thesis points out that the government needs to have the financial resources necessary to master energy development in an environmentally friendly manner by restructuring the energy tariffs so that it can reach its development goals by 2030 in a sustainable manner while also providing long-term energy security.

In a nutshell, although evaluating sustainability in the energy sector is not a black or white question, this paper finds that the second pillar (i.e. environmental consideration) to be the most vibrantly improved, not necessarily on the basis of meeting international standards, but rather on the ground that it was able to make the most progressive improvement compared to the baseline studied year. Even though the country has improved its energy security over the last ten years, this study did not find major improvements in the strengthening of energy security. Electricity tariffs, for example, after being raised a couple of times during the studied period, are still among the lowest in the ASEAN, and as such, a critical threat to the functionality of the sector.

In a modern society, sustainability in the energy sector has a vicious circle within itself and in relation to other sectors – without making the energy sector sustainable, the broader sustainability of the whole country cannot be achieved. Likewise, the journey for broad sustainable development of the whole country is much dependent upon the sustainability of the energy sector, to a certain extent. Before the country can transform itself into a sophisticated, energy efficient economy which will de-carbon, it is fundamental that Myanmar's energy sector is as clean and sustainable as possible. For instance, suppose the country decides to convert its automobiles into electric vehicles without energy sources being sustainable? Such a proposed conversion will not achieve its intended results.

By developing a triad conceptual framework (i.e., energy security, progressive environmental consideration, and financial health) based on existing and contemporary literature, this paper attempts to stimulate a new debate concerning sustainability in the energy sector in Myanmar. One important question to note, however, is whether this triad approach guarantees or generates utopian, perfect sustainability in the energy sector. The answer is rather "no" as it will not lead one's country, particularly as to Myanmar, to an ultimate sustainable energy sector. However, as discussed, sustainability is only a "process," as there is no perfect sustainability (as one cannot say he or she is too healthy. The healthier one is, the better it is.) Although the ongoing political chaos in the country certainly makes the future development of the country and its energy sector hard to predict, it is worth noticing just how far Myanmar was able to achieve over the past ten years in the journey towards a sustainable energy sector and how it can do better moving forward.

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