Electrification of Rural Areas in Developing Countries

Masterarbeit

zur Erlangung des akademischen Grades „Master of Science (M.Sc.)“ im Studiengang Wirtschaftsingenieur der Fakultät für Elektrotechnik und Informatik, Fakultät für Maschinenbau und der Wirtschaftswissenschaftlichen Fakultät der Leibniz Universität Hannover

vorgelegt von

Name: Kretschmar [redacted] [redacted] Vorname: Nikolai Alexander [redacted]

Prüfer: Prof. Dr. Michael H. Breitner

Betreuer: M. Sc. Tobias Kraschewski

Hannover, den 02. Dezember 2020

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1 Introduction

This master thesis focusses on the electrification of rural areas in developing countries with focus on Thailand. The scope is to analyse and evaluate the potentials of energy sources for rural areas of Thailand, especially of renewable energy sources. This chapter outlines the relevance as well as the objective of the topic and introduces the structure followed.

1.1 Relevance and Motivation

Global energy demand has been significantly increasing over the past decades. Electrical demands form a core component of global energy consumption and have vastly expanded consequently. The highest increase in demand and consumption of energy can be detected in Southeast Asia.[1] Especially, electrical energy plays a major role in rural areas of developing countries. The rising demand for electricity of rural areas causes electrical prices to spike. These developments raise the question of where the energy to generate electricity can be harvested in order to sufficiently and reliably supply rural areas of developing countries with electricity.

Overall, the rural population form a global minority. Approximately 72 % of the world's population is considered to be living in urban areas. This value is predicted to increase to 77 % by 2025.[2] Urban areas are defined as regions that surround a city and include towns, cities and suburbs. Urban areas are usually more developed, with a superior infrastructure to rural areas.[3] Overall, the electrification of rural areas is far below the electrification rate of urban areas. Only marginally more than 80 % of the rural population is electrified according to the definition of the World Bank.[4] This is why, it is important to address the electrification of rural areas in developing countries. Due to rural areas remote location they tend not to be interlinked with electrical grids of urban areas.

One of the United Nations' (UN) sustainable development goals (SDG's) is to ensure universal access to reliable and sustainable electricity by 2030.[5] This goal is divided into two parts. Firstly, universal access to electricity. This includes access to electricity for all rural areas in developing countries. This could be achieved through the use of non-renewable energy sources such as the fossil fuels. However, the second aspect of the United Nations' sustainable development goal entails a focus on clean and

[1] Cf. International Energy Agency (ed.) (2019a).
[2] Cf. European Journal of Public Health (ed.) (2015), p. 19.
[3] Cf. United Nations Human Settlements Programme (ed.) (2006), p. 6.
[4] Cf. The World Bank (ed.) (2018a).
[5] Cf. The Global Goals (ed.) (2015).

reliable electricity. This, by definition, limits the expansion plans to sustainable sources. The use of fossil fuels to produce energy thus generating electricity entails universal disadvantages. One of these disadvantages is that fossil fuels emit greenhouse gases. Greenhouse gases contribute and lead to global warming, which is predicted to affect all life on earth. Thus, it is important when addressing the electrification of rural areas, to focus primarily on renewable sources of energy. This underlines the topical relevance of clean energy generation in rural areas.

1.2 Objective

The objective of this thesis is to examine, how the electrification of a rural area in a developing country could be improved in order to reach sustainable development. As a focus point this thesis will study the case of Thailand using recent statistical data to assess the individual opportunities and shortcomings. The case study data may give some first indication for further research in other countries, especially for those in rural areas. The following research questions arose as the core focus of this master thesis:

1. What is the status quo and potentials of different energy sources to electrify rural areas of developing countries, such as Thailand, to meet rising demand for electric energy?

2. What is the current situation of rural households in Thailand and how could the identified potentials be applied in practice?

Primarily the fundamentals chapter will shed light on the process of electrification relevant to the first research question. In order to get a deeper understanding of the topic, statistics about the world electrification rate as well as the electrification of rural areas and of Thailand have been incorporated. Subsequently, the relevance of electrification, especially for rural areas, is addressed in Chapter 2.4 focusing on the importance and necessity of electrification for education, economic growth and healthcare.

Chapter 3 focusses on the use of renewable and non-renewable sources of energy to electrify rural areas of developing countries. At first, a statistical background is established, which focuses on the energy consumption, the share of energy consumption and the generation of electricity. These topics include the current status quo of the energy and electricity consumption of the world and the addressed developing country Thailand. The second part of Chapter 3 focusses on non-renewable energy sources and evaluates their potentials in reference to rural areas of developing countries such as Thailand. In order to examine the potentials, functionality and current use of the different sources of energy, Thailand is compared to the rest of

the world in Chapter 3.2 and 3.3. In chapter 3.3 advantages and disadvantages of renewable energy are established in pursuit of examining, which source of energy have the highest sustainability and reliability success potential to electrify rural areas of Thailand.

Chapter 4 focusses on the second research question, the basis of which is the Thailand Vietnam Socio Economic Panel (TVSEP). In the TVSEP project focusing on rural households and investigating three provinces of each Thailand and Vietnam. The potentials established in Chapter 3.3 will be linked to the survey data to assess the implementation possibilities. Chapter 4 first focuses on the current wave of the TVSEP survey which was conducted in Thailand only. Afterwards, in order to explore the potentials, the rural households of Thailand have been addressed with reference to relevant questions from the survey. To exemplify the potentials of renewable energy, a village called Muang Samakki of the province Buriram has been considered.

5 Conclusion and Future Prospects

In summary this master thesis has set out to shed light on the potentials of electrification of rural areas. This study has shown that electrification is crucial for the development of rural areas of developing countries. The shift from 75 % to 82 % electrification between 2014 and 2019 shows progress despite, clearly underlining the remaining shortcomings. Access to electricity is a vital factor contributing to sustainable development, due to its direct linkage to other aspects such as education, economic growth or healthcare. Electrification is crucial to allow for effective education schemes. Electrification leads to higher productivity and efficiency of businesses, which is pivotal for economic growth. The use of electrified technologies for lighting and cooking among other things help to forgo the use of conventional methods which harm humans.

According to the sources of the IEA, Thailand's rural population is fully electrified, and every household has access to electricity. However, despite being electrified, the rising demand for electricity by households of Southeast Asia leads to electricity being a scarce good. Therefore, the first research question of this master thesis focuses on the current status quo of the electrification of a developing country such as Thailand. Furthermore, it is questioned what the potentials of different sources of energy are and how each source could help to encourage a sustainable and reliably electricity supply for rural areas of Thailand. Currently, natural gas is the main source of energy to produce electricity in Thailand. Around 64 % of the electricity is gathered from natural gas. Coal, also a non-renewable energy source, makes up 18 % of the country's electricity production levels. Biomass as a renewable source makes up nine percent of the current electricity generation of Thailand. However, due to the sustainability targets, the potential of these sources is limited. Particularly coal and natural gas as fossil fuels, emit greenhouse gases and contribute to global warming. Currently for the entire world 27 % of the greenhouse gases arise from the production of electricity. In order to have a sustainable future, the use of non-renewable energy sources must be minimized. Biomass despite being considered as a renewable source of energy is not considered as a viable option either as the combustion of biomass materials also releases carbon dioxide. Nevertheless, as the growth of new organic matter converts the carbon dioxide back into oxygen it is considered to be carbon neutral. Furthermore, the regrowth of trees is time intensive, with the reliability target of the UN framework.

Renewable sources of energy convey potentials in order to compensate for the rising demand for electric energy in Southeast Asia. As this master thesis primarily focusses on Thailand as a developing country, only options viable in Thailand were considered in this thesis however, this list is not exhaustive and may differ for other nations. Hydropower, for example is a popular renewable energy source in the world, however

in order to produce electricity from hydropower certain criteria have to be met. The topography of Thailand does not allow high amounts of electricity to be produced from hydropower. This is underlined by the low usage rate in Thailand compared to the rest of the world. Geothermal and tidal power are also often seen as energy sources with high potential. Nevertheless, as they are limited to the topography of a country, like all renewable energy sources, the use of geothermal and tidal power is also not very popular in Thailand and does not portray much more potential.

Solar and wind energy are renewable energy sources which could compensate for the rising demand of electricity in a rural area of a developing country. Similar to the other renewable sources of energy, they are dependent on geographical and metrological conditions of a rural area in order to produce electricity. This indicates that under certain conditions the energy production of these sources is not secure. When investigating Thailand, solar and wind energy both display huge potentials to produce electricity due to the countries' conditions. Offshore wind in the gulf of Thailand portrays an energy potential of 15 TWh, which is more than five times the amount of electricity currently produced in Thailand from all types of wind energy thus having the potential to vastly increase the countries energy production. In total it is estimated that Thailand has wind energy potential, twelve times higher than the current total production of wind energy. Additionally, onshore wind potentials are mostly concentrated in Northeast Thailand. This shows that wind energy could be exploited to a further extent in order to sustainably and reliably supply regions of Thailand. Solar energy also portrays huge potentials for rural areas of Thailand. The production of electricity by solar systems is affected by different factors, as PV systems are also dependent on their location. Northeast Thailand also has huge potentials especially for PV solar systems, as there is a high radiation of the sun in this area. The implementation of 50 solar parks each of an average the size of ten soccer pitches could already more than double the amount of electricity produced from solar energy. Thailand currently produces more electricity from solar power compared to the rest of the world proportionally. The potentials of solar energy in Thailand are even higher, as solar panels can also be implemented for the residential use. Solar PV systems could be installed on the rooftops of houses in areas where the PV potential is high in order to generate vast amounts of electricity.

The second research question focused on the TVSEP survey. With the use of the data from the current wave of 2019, which investigated over 220 villages in three provinces of Thailand, an analysis of the current situation for rural households of Thailand was conducted. The analysis shows that despite the IEA declaring all rural households of Thailand to be electrified, not all households have used electricity as their major source

of fuel for lighting. Further, perhaps more surprisingly, it became apparent that only 33 of the 2200 investigated rural households used electricity as their major source of fuel for cooking. This can be tribute to various explanatory factors, the most plausible being the lack of supply of electricity. If the rural area is not supplied with enough electricity to meet the demand, alternative sources for cooking such as gas, coal or firewood will be used.

A rural village of the TVSEP survey has been explored in further detail. The village Muang Samakki is located in the center of Northeast Thailand, which is the area with the highest potential for the renewable energy sources of wind and solar energy. From the study it was remarkable that only seven from ten households used electricity from the net as their major source of fuel for lighting. Kerosene, firewood and gas was each used by one of the remaining ten households. Furthermore, half of the households in Muang Samakki use gas as their major source of fuel for cooking. Electricity from the net was only used by one rural household as their major source of fuel for cooking. This shows that electricity from the net is barely used in Muang Samakki. However, as Muang Samakki is located in Northeast Thailand, there is a high potential for solar and wind energy. According to the study from the TVSEP survey, almost one third of the participants are occupied in the agricultural business. The analysis of Muang Samakki detected that in more than half of the interviewed rural households, at least one family member worked in their own agricultural business. Currently the land is primarily used for farming. As wind turbines do not utilize huge amounts of land, these turbines could be installed in combination with regular agricultural business on the land. Moreover, the land could potentially be used for electricity generation through PV solar systems. Additionally, the PV solar systems could be installed on rooftops in Muang Samakki. As this rural village portrays the potentials for wind and solar energy, these measures could be implemented in order to produce enough electricity to compensate for the rising demand. Furthermore, the use of solar PV systems and wind turbines on closely located land, could allow an off-grid supply of electricity for a rural area. This could additionally reduce the dependency on electricity from the net.

The government of Thailand promotes the use of renewable sources of energy to produce electricity with financial measures. However, the construction of a wind turbine or a solar PV system is combined with a huge financial investment which cannot simply be overcome by a regular rural household. Renewable energy sources are necessary for a sustainable development of a rural area. Nevertheless, the renewable sources of energy such as wind or solar energy, which are the only sources that display huge potentials, are dependent on weather conditions. Non-renewable energy sources are less dependent on factors which influence their efficiency and productivity. Therefore,

the non-renewable sources of energy will still remain a part of the electricity production in the future in order to compensate demand at peak time, as in these periods the amount of energy produced from non-renewable energy sources is too low. In conclusion the use of renewable energy sources has to be promoted to a greater extent. However, non-renewable and renewable energy sources will likely both be present in the generation of electricity in rural areas of developing countries in the near future.