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Small-scale biogas plants in Vietnam: How are affected by policy issues?

MASTER'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled “Small-scale biogas plants in Vietnam: How are affected by policy issues” independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague date

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Sheriff Noi

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Abstract

Both developed and developing countries are working towards creating an emission free planet. Vietnam, as one of the highest contributors to greenhouse gas emissions, has put in place several policies to curtail this phenomenon. Most of these policies are geared towards the development of renewable energy technologies like biogas. The country's policy on environmental protection, clean energy, climate change and rural development has been centred on small-scale biogas programmes and projects. However, how are these small-scale biogas plants affected by arising policy issues? To answer this question, an intensive literature review with biogas experts with a focus on Vietnam was done. Gathered data were analysed using the policy cycle analytical approach. The results showed that several policy instruments like price of other conventional fuels and feed-in-tariffs affect small-scale biogas plants. Furthermore, thousands of small-scale biogas plants have been installed due to good policies like Vietnam National Biogas Programme. Finally, funding remains the biggest barrier to biogas policy amendments and implementation; the several biogas programs implemented over the decade could have yielded more positive impact if financial barriers like co-financing by the beneficiaries would be set-up more appropriately. Also new policies in the future will favour mid to large-scale biogas plants rather than small-scale biogas plants. This policy implication threatens the sustainability of small-scale biogas plants; therefore, policy makers must be adroit in addressing policy issues that affects biogas production in Vietnam.

Key words: biogas; Vietnam; policy; small-scale biogas plants; renewable energy; rural development

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List of the abbreviations used in the thesis

ASEAN	Association of Southeast Asian Nations
IRENA	International Renewable Energy Agency
UNDP	United Nations Development Programme
APEC	Asian Pacific Economic Cooperation
OECD	Organization for Economic Cooperation and Development
FAO	Food and Agricultural Organization
NDC	National Determined Contribution
BAU	Business as Usual
SNV	Dutch Development Organization
VNBP	Vietnam National Biogas Program
UNFPA	United Nations Fund for Population Activities
ISO	International Organization for Standardization

1. Introduction

Developing countries across the world are challenged with inadequate energy supplies and energy efficiency for significant economic development. They are mostly dependent on other conventional fuels and burning solid biomass for charcoal production. Also , an increase in economic growth has led to a high rate of greenhouse gas emissions (Raupach et al. 2007; Steckel et al. 2011), environmental pollution arising from animal manure in connection with climate change and human health is also on the rise in these countries (Shane et al. 2015). This led to the drafting of the United Nations Convention on Climate Change in 2015 with the aim of keeping global warming below 2 °C. Asia produces large quantities of manure most especially from livestock and poultry production(Vu et al. 2015) which contributes enormously to global warming. Vietnam has a vibrant livestock sector with its pig sector constituting 80% of its total meat production and provides a livelihood for millions of small-scale farmers (Nga et al. 2014; Thi et al. 2015). It has played a significant role in Poverty reduction and income distribution among highly poor Vietnamese farmers (Roubík et al. 2017). With an increasing demand for pork in Vietnam , there has been a shift from small-scale livestock farms to large-scale over the past decade (Nga et al. 2014; Dinh 2016), demonstrating the increasing growth of the livestock sector. Consequently, these farms produce large amounts of manure daily; this has brought the country into an animal waste management crisis. Over 40% of these waste is dumped in rivers and canals, causing water, soil and air pollution (Dinh 2016). In addition, due to economic growth and rapid power consumption, Vietnam is facing energy supply problems and thus has been reliant on imported electricity, steam coal and oil (The World Bank 2010).

To simultaneously solve the problems of energy supply inefficiencies and environmental pollution, the government implemented the National Biogas Program (Roubík et al. 2020); biogas technology had the potentials to solve these problems (Thien Thu et al. 2012). The technology has helped in the mitigation of environmental pollution, energy supply, job creation in rural communities (International Energy Agency 2020), and the build-up of a commercially viable biogas sector in the country; the sector is growing rapidly over the years. Several authors have performed excellent analysis and reviews on the potentials of the biogas sector in Vietnam through manure

management and quantification, small-scale biogas plant assessments, anaerobic digesters, contributions to greenhouse gas mitigation, financing small-scale biogas plants, addressing biogas problems and opportunities, biogas as a sustainable renewable energy (Nguyen 2011; Thi et al. 2015; Vu et al. 2015; Anh 2016; Roubík et al. 2016, 2017, 2018a, 2020) and the like. Furthermore, policies are instruments used to regulate and guide the decisions of sectors for good rational outcomes, however, how policies affect small-scale biogas plants in Vietnam is a gap that is yet to be fulfilled.

2. Literature review

2.1. Sources of Energy in Vietnam

In general, over the past 15 years, the region of Association of South East Asian Nations (ASEAN) has experienced more than 50% increase in energy demand (Gould et al. 2017). Among the South Eastern Asian countries, Vietnam is one of the countries that consumes enormous amount of energy (MOIT & DEA 2017), thus, relies on an energy mix from both renewable and non-renewable sources such as coal, uranium, hydropower, natural gas, biofuels and oil (Khanh Toan et al. 2011; Report 2017; Shem et al. 2019a). It also has hopes of covering some of its energy sources from geothermal energy (Shem et al. 2019a) and nuclear energy. The first nuclear powerplant was expected to be established by 2020 and is expected to cover 10% of electricity production (Decision 1208/QD-TTg 2011), nevertheless, there are no nuclear plants in Vietnam yet .This prospect is expected to worsen the emissions from the energy sector by doubling its current state by 2030. In addition, Vietnam has good potentials for wind energy production when compared to other countries within ASEAN. It also has good solar resources for energy production (Khanh Toan et al. 2011). The quick exploitation of both renewable and non-renewable energy sources (International Renewable Energy Agency (IRENA) 2018) and economic growth in Vietnam has resulted in increased energy demand (Asean Center for Energi 2015; MOIT & DEA 2017; Report 2017). The country has also moved from the use of traditional biofuels and hydropower to a heavy reliance on fossil fuel due to the rapid growth(ADB 2016; ECA 2016). Rapid industrialization, expansion of motorized transport and household electrification has been the key contributors to the rise in energy consumption (Duc Luong 2015), energy consumption further increased after the national electrification program was introduced (Khanh Toan et al. 2011). According to the Asian Development Bank (2016), Vietnam has shifted from being an energy exporter to an energy importer. This had led to high cost of energy in the country due to higher tax levies (Nong 2018) and energy insecurity(Nguyen 2007). It was estimated that the country will import approximately 49% of its total primary energy demand by the year 2015 (Minh Do & Sharma 2011). However, according to IRENA (2018), Vietnam has been self- sufficient for its energy

needs since 2013.The government of Vietnam owns, distributes and generates a larger share of the electricity produced in the country(UNDP 2012). The major sources of electricity are coal, hydropower and gas (Asean Center for Energi 2015; Report 2017). Even though some parts of the country also has difficulty in accessing the national electricity grid (Zimmer et al. 2010), more than 50% of households have access to electricity (The World Bank 2010). However, the difficulty was the ability of a larger percentage of people to get assess to clean energy and technology for cooking (Messent et al. 2018). Although energy access for the entire nation was achieved in 2016, technology for cooking and clean energy was only available to half of the country's population in 2014 (Shem et al. 2019a).

In the 20th century, majority of Vietnam's energy demand was covered by renewable sources, most especially hydro and biomass energy. Biomass played an important role in energy provision when the country was agricultural oriented. Even though its role within the energy sector has declined over time, within the year 2005, it was estimated to have contributed to one third of total energy consumed within the country. Due to the low growth of biomass energy usage, availability of commercial fuels and untapped hydropower, the contribution of renewable energy to total energy was expected to drop by 40% in 2005 and more than 10% by 2030 as the economy develops (Khanh Toan et al. 2011). However, in current times the high percentage of the demand is recurrent for fossil fuels(Zimmer et al. 2015). Diesel oil is the most consumed petroleum product within the country (Khanh Toan et al. 2011). The country's carbon emissions within the energy sector has increased enormously from 1971 to 2010 (Zimmer et al. 2015). The share of greenhouse gas emissions from Vietnam's energy sector is presumed to be three-quarter of total emissions produced by the country by 2030 (World Bank 2011). In the years 2000-2010, coal increased the carbon emissions form the countries energy sector at a range of 5% per annum. The emissions within the energy sector has reduced over time, nevertheless it's still very high when compared to other industrialized countries (Steckel et al. 2011).

2.2. Overview of Energy Policies in Vietnam

Energy plays an important role in transforming our environment into a sustainable one (Everett et al. 2012). To develop energy within the country, the government has developed a national plan known as the National Energy Development Strategy. Some of the elements within the policy includes; increasing the share of renewable energy to total energy supply by 3% in 2010, 5% in 2020, 5% in 2025 and 11% in 2050 (Khanh Toan et al. 2011; Quirapas et al. 2015; Chang et al. 2016). Also, in 2010, the energy sector of Vietnam was reformed through the introduction of the National Master Plan for power Development and Law on Economical and Efficient Use of Energy (Decision 1208/QD-TTg 2011). The plan indicates the share of electricity that must be produced by renewable energies (except for hydropower). Renewable energies should account for 4.5% of electricity produced in 2020 and 6% in 2030. Energy efficiency and conservation polices where not left out in its policies. According to Duc Luong (2015), Energy efficiency and conservation polices should not only aim at improving or meeting current energy efficiencies, it would also aim at meeting an increase in energy demand in the future. Vietnam's energy efficiency and conservation policy, known as the National Energy Efficiency Program, only aimed at saving total national energy consumption for a short period. The program started in 2006 with a target of 3-5% from 2006 to 2010 and 5-8% from 2011 to 2015 (Minister 2018a). The program also experienced a lot of lapses (Minh Do & Sharma 2011). There was no policy coherence in the promotion of energy efficiency and conservation due to limited information on technologies, inadequate data for analysis of potentials for energy efficiency improvement and financial constraints (Duc Luong 2015). In addition, there is the need for environmental protection in the production of energy. The energy sector has been identified to contribute to more than 50% of greenhouse gas emission (Report 2017) .Vietnam has a detailed environmental plan implemented in 1991. It is known as the National Plan for Environment and Sustainable Development. It contained polices and strategies that aimed at promoting the energy sector and at the same time ensuring a clean and healthy environment. One of such polices what the Environmental Protection Law which came into effect in 1993 (Minh Do & Sharma 2011). There are two major environmental protection acts in Vietnam; enacted in 1993 and 2005. The main aim of these acts were geared towards investments in environmental protection

and policies, however Environmental laws in Vietnam are not substantial (Wesseler 2010). Another policy is the Green Growth Strategy. It was developed by the Ministry of Planning and Investment. The ministry is also responsible for making allocation of funds and coordinating activities related to energy proposals (Report 2017). The Green Growth Strategy is an energy development strategy by Vietnam which started in 2011 to 2020 and with a vision to continue to 2050 with the aim of reducing climate change. Policy instruments and mechanisms have been put in place to help reduce the emissions from the building and transport sector (Shem et al. 2019a). The country's energy policies are mainly focused on climate change, electrification ,efficiency and renewable energies (Gould et al. 2017). However, for Vietnam to achieve most of it actions aiming at reducing climate change to its target level, it would have to seek for external funding (Government of Vietnam 2015).

A critical review and assessment of energy policies in Vitenam by different researchers raised a lot of criticism and arguments. According to Minh Do & Sharma (2011), to solve the problem of carbon emissions arising from increased in energy demand, Vietnam has implemented several policies. However, a critical review of these polices only focus on supply options that meet sectoral demands and neglects cross-sectional issues arising from the interdependences between the economic and energy sector. Also, for low-income people in remote areas to have access to affordable energy, its very salient for energy policy makers to pay critical attention to accessibility and affordability. It is likely that poor energy infrastructure, security and supply would be the main concern Vietnamese policy makers. Shem et al. (2019) was also of the same view that energy policies in Vietnam were bias and thus skewed one side by the driving force of energy supply instead of considering consumption. A review of energy policies in Vietnam shows that there were similarities in achieving the objectives of climate change, electrification, efficiency, and renewable energies. There was a lack of coordination, enforcement and tangible outcomes for policies aiming at low carbon emissions. A review of Vietnam's energy policies by Shem et al. (2019) using policy taxonomy indicated that, there was no relationship between the effective progress of energy policy portfolio and year of application. Nevertheless one-third of policy suite established since 2014 coincided with the adoption of the Sustainable Development Goals and the ratification of the Paris Agreement on Climate Change. Also, financial, institutional, information gaps and technical barriers were hinderances to policies

enacted to achieve low carbon transitions (Report 2017). There is need for a policy coherence between all existing policies to reduce overlapping (Wilkinson 2011; Huttunen et al. 2014). A system for monitoring implemented old and new polices should be available to help track progress and propose possible reforms. Shem et al. (2019) then concluded that, to achieve a successful implementation of a cleaner future and good pathways towards zero emissions, Vietnam would have to consider useful and effective government support, increase opportunities for renewable energy potentials and a reformation of the energy sector that brings about competition and, energy policies should have a clear purpose, encourage external partnership and cooperation, and have a criterion for measuring progress and impact.

2.3. Renewable Energies

Renewable energies have great potentials for energy generation (Full Advantage Co. Ltd. & PITCO Private Limited 2017), economic growth and energy security (Aguirre & Ibikunle 2014). They are less harmful to the environment when compared to non-renewables (Adams et al. 2018; Hu et al. 2018). By developing into a mainstream technology, renewable energies contributed enormously to global power generation capacity in 2017 (Hille et al. 2020). Governments in the South East Asian region are developing and encouraging the use of renewable energy sources within the region (Chang et al. 2016; Hu et al. 2018). The resource is in abundance within the region and can stimulate economic growth as population increases (Jakica 2018; Obeidat 2018). There is only a small share of renewable energy development and use within the south-eastern region because of bureaucratic processes involved in getting permits, non-existent and slow implementation of existing policies, fossil fuel subsidies, political, social, and economic pressure. The biggest impediment to renewable energy technology is awareness, accessibility and affordability (Erdiwansyah et al. 2019). Its share in electricity generation in Vietnam is estimated to 23% by 2030 (Asia Pacific Economic Coorperation (APEC) 2013). For renewable energies to be integrated among the people, there is the need for international support, strong incentives, and financial mechanisms supporting renewable energy technologies. Although such transitions can be very costly, they strength the growth of rural communities; it's unclear if the government of

Vietnam is ready for such transitions (Shem et al. 2019a). Governments and policy makers must consider renewable energy investments as a pillar for sustainable development (Erdiwansyah et al. 2019).Vietnam's power sector reform can increase the integration of renewable energies. Successful integration of renewable energies will lead to achieving more than one sustainable development goal (International Renewable Energy Agency (IRENA) 2018). Renewable energy installation capacity increases as energy policy suite develops. The suite supports renewable technologies like biogas and other sources (Shem et al. 2019a).One of the hurdles in the promotion of renewable energies in Vietnam is the low cost of electricity and coal prices, it creates a much more stringent competition. It has also restricted investment in the sector (Report 2017). Research and development helps to facilitate the adoption and use of renewable energy technologies (Liu et al. 2019). Governmental and non-governmental organizations, academic institutions and several agencies in Vietnam are interested in research in renewable energies (Duc Luong 2015). Research and development support of renewable energies is greater when partnered with feed-in-tariffs (Lindman & Söderholm 2016). Renewable energies need a competitive environment for polices to have a good impact.

2.4. Renewable energy policies

A review of renewable energy policy instruments from the International Energy Agency by Pitelis et al. (2020) over the year 1990-2014 revealed that renewable energy policies have been successful in fostering innovations in renewable energy technologies .To mention only a few policy instruments for renewable energy technologies, Hille et al. (2020) identified tax reduction, greenhouse gas certificate trading, renewable energy quotas (with and without trading certificates), renewable energy targeting, feed-in tariffs, research and development programs, tax credits and low cost loans. They influence each renewable energy technology differently (Nesta et al. 2014; Pitelis et al. 2020). Even though policy instruments affects each renewable energy differently , by evaluating renewable energy support policies among 25 OECD countries, Johnstone et al. (2010) found out that environmental regulations generally affects innovations positively. The internalization of pollution cost by renewable energies should serve as a path way for enjoying incentives from public policies (Liu et al. 2019). Most

comprehensive renewable energy policies and instruments support innovations related to wind and solar energy (Hille et al. 2020). Financial incentives, obligatory schemes ,quota and mandatory requirements, enormously impacts on renewable energy application in a positive light (Bird et al. 2005; Menz & Vachon 2006). Pitelis et al. (2020), argued that demand-pull policies can facilitate innovations in renewable energy technology as compared to other policy instruments. Besides the many benefits of the use of policy instruments, they can also pose to have some disadvantages. By analysing the public policies regarding renewable energies among 29 countries over a time span of 15 years, Liu et al. (2019) identified grants and subsidies for renewable energies as a common policy adopted by all countries. The subsides helps to increase renewable energy output by reducing cost of equipment and production cost. Nevertheless, they found out that tax instruments do not encourage the development of renewable energies. They emphasized that, even though tax incentives increase competitiveness, they need a stable policy environment since they can be affected by change in government administration and economic crises. Also, the functions of carbon markets of renewable energy are distorted by targeting (Moselle 2011; Nordhaus 2011).

Renewable energy polices have existed in Vietnam for more than a decade. In 2003, the Vietnam government, the 'Decree on Energy Conservation and Energy Use' as part of its electricity laws. The promotion and use of renewable energies were part of this policy. The policy provided subsides for capital investment for renewable technologies, preferential tariffs for renewable energy products and loans (Khanh Toan et al. 2011). Also, in March 2016, the National Power Development Plan Vision 7 policy was implemented to increase the share of non-hydro renewables(Report 2017). Its target was to increase renewable energies power generation capacity by 12.5% by 2015 and 21% by 2030. The country plans to increase the share of renewable energy in primary energy to 32.3% and 32% in electricity production by 2030. The share of renewable energy to electricity production is at a shortfall, it has become less prominent as coal and gas is emerging. In 2016, the Support systems for renewable energies like biomass , wind and solar has opened the country to private sector investment and the integration of these technologies at all planning levels within governance (Report 2017). Standardized Power Purchase Power Agreements and feed-in tariffs is the main policy instruments being used to promote renewable energy power projects in Vietnam; they have impacted significantly on small hydropower project developments. Instruments

such as financial subsidy, soft loan and capital subsidy were also used as incentives. To mention a few , the other policy measures that were put in place were the development of renewable energy projects in rural areas , using renewable energy sources for demonstration projects and encouraging local manufacture of renewable energy equipment (Full Advantage Co. Ltd. & PITCO Private Limited 2017). The tariff has been adopted for solid waste, small hydro power, solar photovoltaic and biomass (Erdiwansyah et al. 2019). They also enjoy import tax exemptions and other incentives(Report 2017). Subsides for fossil fuels existed until 2020 when attention has now been shifted to the use of clean energy to help mitigate greenhouse gases. The removal of this subsides is estimated to have only a little effect because the subsides were predominantly for oil and gas and this could cause a shift to the use of other alternative conventional fuels like coal or nuclear(Shem et al. 2019a). Even without subsidies, projects focusing on renewable energies are economically less competitive when compared to other alternatives (Wang et al. 2012, 2013), conversely , a study in China identified that without subsides, biogas projects are not profitable (Wang et al. 2016). Strong renewable energy policies prevail in Vietnam nevertheless, other approaches accompanied with specific renewable energy laws are yet to be considered. (Shem et al. 2019a). In the US, democratic representatives, non-governmental organizations and customers who patronize green innovations were identified to facilitate the transmission of policies in renewable energies (Delmas & Montes-Sancho 2011). For a success in the use of clean energy, Vietnam would have to develop an appropriate legal framework that encourages energy security, technological advancement, private, international and government cooperation(MOIT & DEA 2017). Vietnam has been successful in the creation of renewable energy polices but measuring its implementation and level of success is difficult.

2.5. Biogas technology

Biogas is a technology that is used to produce a mixture of gases from organic matter with the absence of oxygen. It can be produced from crop residues , poultry and livestock manure (Shailendra et al. 2015). Digestion of organic waste to produce biogas comes in four stages with varying species of bacteria that act at different environmental

conditions, yield produced depends on biochemical reactions and feed stock composition (Comino et al. 2010; Yue et al. 2013; International Energy Agency 2020). Biogas produced from crop residues yields higher than when produced from livestock manure (World Biogas Association 2019; International Energy Agency 2020). Some farmers are unaware of the biomass biogas potentials and thus feeds their digesters with only manure (Roubík et al. 2018b). The main constituent of the gas produced is methane and carbon dioxide ; it's by product (digestate) can be used as organic fertilizer and the restoration of infertile land (Mottaleb & Rahut 2019). The digestate is rich in potash, phosphate and nitrogen (World Biogas Association 2019). Methane is the most valuable energy obtained from biogas (Tucho et al. 2016), ranging from 45% to 75% by volume. This and small quantities of other gases can produce energy for cooking and heating (International Energy Agency 2020); biogas stoves have been designed to be suitable for cooking local foods (Tumwesige et al. 2014). However, the application of modern technologies through purification and separation has made it possible for it to be used as fuel in vehicles, injection into natural gas networks and for electricity generation (Tucho et al. 2016; Chen & Liu 2017; Chen et al. 2017). The Septic tank is the oldest biogas system to be constructed and was used for waste treatment in the 19th century, however, the biogas produced in the tank was never collected and used (Jørgensen 2009). The main technologies used in biogas production are landfill gas recovery system, wastewater treatment plants and biodigesters; small, medium, and large biodigesters. Mentioning a few, the types of digesters are, India digester, Chinese fixed dome digester and floating drum (Kumar 2012); basic and advanced biodigesters are the household biogas technology often used by households. Each of the technology serves different use and comes with its pros and cons The choice of biogas technology depends on policy goals and local circumstances (International Energy Agency 2020). Biogas got much attention in the 1970's during the oil crisis. This triggered a lot of research and experiments about the technology and eventual made it to gain approval in African, Asian, European and American countries (Bond & Templeton 2011), and now millions of biogas plants has been installed worldwide (Steiner & Kandler 1984). It's now the most prominent and emerging renewable energy technology (Mao et al. 2015). In Vietnam, biogas development erupted in 4 different timelines; 1964-1975; 1976-1980; 1981-1990 and 1991 till date. Each time period is associated with some level of potentials and limitations; however, the technology had significant development during

the 1991 time period when approximately 2000 household biogas digesters where established (Wesseler 2010). Nevertheless, there are disparities in the application of the biogas technology between developed countries and developing countries because developed countries have a better manure industrialized system, highly educated working force and more extensive infrastructure for the utilization of biogas (FAO 1996; Arthur et al. 2011). Also, within a country, production capabilities may vary due to climatic conditions, available biomass resources, level of technology ,socioeconomic status and commercialization (Gu et al. 2016). Because the technology produces a sustainable form of energy, can contribute to the attainment of the Sustainable Development Goal on clean and green energy (Mottaleb & Rahut 2019; International Energy Agency 2020), reduces deforestation resulting from charcoal production, has positive effect on woman empowerment and reduction of indoor air pollution related diseases (Katuwal & Bohara 2009) , helps reduce greenhouse gases, protects water bodies and improves the quality of life of marginalized farmers(World Biogas Association 2019), it has been largely supported by several governments and international organizations (Møller et al. 2004; Eriksson & Olsson 2007; Roubík et al. 2017; Xue et al. 2020). It also helps reduce the dependency on fossil fuels and protects ecological resources (Gao et al. 2019); in China, it was estimated that biogas replaced tons of coal per year and contributed positively to energy security (Xue et al. 2020). The World Biogas Association has emphasized that, the efficiency of the biogas industry can help achieved 9 out of the 17 sustainable development goals(Bartoli et al. 2019; World Biogas Association 2019). The technology has been wide spread in developing countries (Bond & Templeton 2011), however is has only been mostly used for lighting and cooking purposes (Deng et al. 2014).

Untreated or improper disposal of animal waste contributes to global warming and can cause nutrient imbalance in soils (Abdeshahian et al. 2016), it also contains microorganisms that pose health risk to humans and animals (De et al. 2003). Conversely, heavy metals present in animal feed forms part of their manure. These metals can have a negative effect on biogas production (Ortner et al. 2014), and could cause damage to the soil, living organisms, water bodies and risk to human health when such digestate are used as fertilizer (Bian et al. 2015). The technology has the potentials to contribute enormously to Vietnam's animal waste management problems and offers additional global warming reduction, environmental and economic benefits (Thien Thu

et al. 2012; Cu et al. 2015; Vu et al. 2015; Roubík et al. 2016), in addition, the potentials for biogas in the country is twice as higher that its current generation (Roubík et al. 2018b). Besides animal waste, human excreta can also be used to generate biogas (Mackie Jensen et al. 2008; Jewitt 2011). The adoption of the technology is faced with bottlenecks such as technical and sociocultural problems (Walekhwa et al. 2009), high cost of installation and operation (Mittal et al. 2018), efficient supply of feedstock to digester (Lwiza et al. 2017) and transport of the energy. In Cuba, farmers use a simple method to store and distribute biogas. The raw biogas is carried in big plastic bags to neighbours who need the gas (Nal 2015). The amount of feedstock fed into a digester have an effect on its operation (Kumar 2012). In Ethiopia, it was identified that, rapid adoption of the technology is impeded by socio-economic problems like low purchasing power of resource poor households, political insecurity and low level of education (Kamp & Bermúdez Forn 2016). The wide use and adoption of the technology in Vietnam is still at its developmental stage with great potentials.

2.6. Small-scale Biogas Plants in Vietnam

The three main categories of digesters within Vietnam's biogas industry are the micro digesters, digesters for generating electricity and scale digesters for producing biomethane. Micro digesters play an important role in rural development and energy security, they are mostly used for heating and cooking. There over 50 million micro-digesters globally (World Biogas Association 2019), more than 100,000 domestic digesters have been installed in Vietnam (SNV and Fact 2014). Different biogas digesters vary in scale and operation technique. Economically, large scale biogas digesters are feasible, nevertheless its same for small-scale biogas digesters too; users do not face any significant opportunity cost in using the system (Wesseler 2010). Small-scale biogas digesters fall under the micro digester category. Small-scale biogas plants have anaerobic digesters which converts organic waste materials into gas, as well as produces fertilizer as a by-product. They provide a comprehensive solution to environmental pollution, hygiene and health issues accruing from biodegradable waste (Roubík et al. 2016), they are advantageous over other forms of renewable energies (Zhang et al. 2013). The most common type of biogas plant is the Chinese type:

millions of households in developing countries use the biogas digesters with the Chinese dome design. Anaerobic digesters have been in existence and usage for more than 30 years in Vietnam (Anh 2016). Small-scale biogas plants provides clean energy for cooking at house hold levels (Mwirigi et al. 2014; Abadi et al. 2017), and lighting for rural farmers. Small-scale biogas plants can help provide energy and maximize the use of scare resources for farmers in developing countries who are unable to afford the installation of large biogas plants due the cost of investment (Limmeechokchai & Chawana 2007; Mwirigi et al. 2009). They also played an important role in farming systems (Roubík et al. 2016). Publication from the media and financial compensations from the government played an important role in the promotion of the small-scale biogas technology in many communities, sources of information regarding the technology was also disseminated by local facilitators and neighbours. In Asian countries where there has been a strong dedication for the use of biodigesters has only nearly been halfway successful (Bond & Templeton 2011; Surendra et al. 2014). There is still the existence of some challenges. Although a lot of small-scale biogas plants have been installed in Central Vietnam, not all farmers have adopted the technology because there is still barrier with financing (Roubík et al. 2018b). Some farmers use their own resources for the construction of the biogas plant (Roubik & Mazancova 2016). Other researchers have also argued that number of small-scale biogas plants was relatively low in proportion to the amount of animal waste produced (Roubík et al. 2017, 2018b). Adoption of small-scale biogas plant can be significantly be affected by age and literacy level of household head (Mottaleb & Rahut 2019), number of farm animals owned , access to physical infrastructure and credit (Katuwal & Bohara 2009; Mengistu et al. 2016; Lwiza et al. 2017). However besides considering some of the above factors , in Vietnam, farmers that use the biogas plant adopted it based on the perception that it was environmentally clean, money saving, provides gas for cooking and produces higher heat than wood (Roubík et al. 2018b).

2.7. Biogas policies

Policies are tools that can be used to drive new technologies. In developing countries, the most common alternative source of energy is by burning of firewood,

which is also a source of environmental pollution and greenhouse gas emissions. Bioenergy policies can help reduce this phenomenon with several added-on benefits. Besides the merits, they can also serve as disbenefits. Bioenergy policies can also have adverse effects on food production. Policies in Europe shows how producing biogas from agricultural waste is a cost-effective way of reducing greenhouse emissions (Nguyen 2007). Nevertheless some of these same policies only focuses on the total biogas production and thus diverting to use of energy crops as food but rather for energy production (Apec 2012). Specifically in Finland , energy policies and strategies were geared toward making bioenergy as the future form of energy (Riku 2017). Problems can prevail when there are no clear cuts between the use of energy crops and food and energy generation, biogas production could threaten food security (Kumar 2012). By Germany revising its renewable energy polices over half a decade, there is the possible that it would lower its subsidy for biogas projects and abolish subsidy on energy crop for power generation (Gao et al. 2019). Policy framework needs to acknowledge the benefits of biogas and should tailor biogas in partnering with food production systems rather than competing with them (International Energy Agency 2020). Advanced biofuels are those considered to have a lower effect on food resources and land use due to the use of waste materials , non-food and non-feed biomass as feedstock for energy generation (Kumar 2012; IRENA 2019). By comparing two biogas policies (old and new policy) in Italy, Bartoli et al. (2019), identified that new policy scheme helped decrease greenhouse gas emissions by promoting the utilization of agricultural waste for biogas production instead of using energy crops. New policies in Europe focusing on sustainability and renewable energy targets have now been fine-tuned to limit the amount of energy crops dedicated to bioenergy production; the concentration has been geared to only the use of agricultural waste and residues (Cherubini & Strømman 2011; Scarlat et al. 2018). Biogas policies should be clear and precise, its targets should be set among other renewable energies. In China's renewable energy policy, the target for total (biogas cubic meters) to be produced among other renewable energies was stated (NREL 2004; Wang et al. 2010).

Making better transfer from biogas policies around the world to Vietnam, within the document Decision no. 153/ 2004/QD-TTg of Vietnam, are policies aiming at environmental pollution, support for environmentally friendly technologies and contributions to the United Nations 1992 Framework Convention on Climate change

(Khanh Toan et al. 2011). In addition, since the 1990s, Vietnam has been part of several climate change negotiations and indirect policies aiming at energy and natural resources, conversely, they only started treating it with much specificity after the National Target Program to Respond to Climate Change policy was introduced in 2008 (Zink 2013; Minister 2018b). After this, another climate policy was introduced in 2011, called the National Climate Change Strategy Policy. This policy redefined climate change mitigation strategies by setting a parallel line between climate change adoption and mitigation, it states that, both should be done separately. The National Green growth strategy policy also followed in 2012 with the aim of combing , energy, economic and climate policy to achieve a low carbon economy (The Prime Minister 2012). The Vietnam National Green Growth Strategy also contrasted the National Climate Change Policy by defining explicitly, the emission reduction target for the energy sector. The Green Growth Strategy made the country to gradually reduce its subsides attributed for fossil fuels (UNDP 2012). It went ahead to also implement cap by introducing certification for greenhouse gas emissions and carbon tax (The Prime Minister 2012). Furthermore, because among the South Eastern Asian countries, Vietnam is the country with the highest greenhouse gas emissions, consequently, being a member of the Paris Agreement in 2015, the government also has an objective to undertake the Nationally Determined Contribution (NDC) to help fight climate change and encourage the use of renewable energy (Third et al. n.d.; MOIT & DEA 2017; Nguyen et al. 2019; Shem et al. 2019a). The Nationally Determined Contribution is to evaluate how climate change will potentially impact vulnerable sectors within the country and prioritize climate change adoption and mitigation actions between the years 2021 to 2030 (Third et al. n.d.). It has a conditional and an unconditional element which covers several sectors but does not cover greenhouse gas emissions from the industry sector (Report 2017). Out of 197 countries, only 181 countries were committed to the Paris Agreement., including Vietnam. The policy aims at reducing greenhouse gas emissions by 8% by 2030 when compared to its Business As Usual (BAU) and also with the help from international bodies, reduce it further by 25% (Government of Vietnam 2015). The strategies would focus on renewable energies and energy efficiency (MOIT & DEA 2017). Vietnam has implemented a lot policies for climate change mitigation, conversely Zimmer et al. (2015) argued that, they did more harm than good. They emphasized that, if not for a global call and externally forced regulation, Vietnam

would have no incentives to engage in climate change policy because they only contribute a small share of the global greenhouse gas emissions. Majority of the climate change mitigation strategies where only envisage measures whose realization are yet to be visible. Its ambitions to reduce climate change through policy instruments and targets is questionable. The country has a significant low-cost potential to reduce carbon emissions , yet they are unexploited (World Bank 2011). Shem et al. (2019), also emphasized that to achieve these targets and fulfil the agreements, Vietnam would have engage in externally with its international partners and internally focus on its policy reforms ,implementation and enforcements within the energy sector.

However, before some of these policies and agreements, the government had already implemented a biogas program that does not only help reduce greenhouse gas emission through proper organic waste management but also helps to produce clean energy for households. Organic waste can produce clean energy and has great potentials for sustainable development (International Energy Agency 2020). To promote biogas development, research and increase the number of biogas plants, the Vietnamese Ministry of Natural Resources amended policies and plans that harmonized the animal husbandry sector with the entire economy (Wesseler 2010). In 2003, the Vietnam government and SNV (Dutch Development Organization) implemented the National Biogas Program. In Central Vietnam, thousands of household biogas plants have been established through this program, the technology has become now become affordable and suitable for small-scale farming (Thien Thu et al. 2012; Ghimire 2013). Thousands of rural individuals from different province have been trained and benefited from this program (Ghimire 2013). Wesseler (2010), is of the view that, the perfect biogas strategy is the SNV project. In contrast, that project is held high esteem by only few provinces within the country. The biogas program is expected to end in 2020. Qu et al. (2013) elaborated that there can be a possible failure of biogas technology adoption when governments halt their biogas programs. To encourage the adoption of new technologies in renewable energies is largely dependent on a governments ability to make them popular in the various communities (Tumusiime et al. 2019). Besides government , the media can play an important role with regards to information on energy policy and available opportunities to inspire different actors to participate in energy production and adoption of new energy technologies (Cox 2010; Sengers et al. 2010; Nygrén et al. 2015). more vivid details about biogas technology were missing in

most newspaper coverage, the technology was always presented as something novel. In Finland, national biogas polices where presented as unambitious by newspapers and therefore was not considered as an important energy throughout the country (Lyytimäki 2018). A review of the biogas program by Shem et al. (2019) revealed that, a successful biogas program can bring about , climatic, economic, food and health benefits to rural localities; the International Energy Agency (2020), made same remarks on the use of biogas. The biogas program was able to deploy 250,000 digesters to rural households across Vietnam over a period of 14 years. This led to employment, increased lighting, good air quality, and environmental pollution reduced. In China, policies have led to the increased in installation of biogas digesters across the country and are putting in more policies that would enable the biogas industry to upgrade to the production of biomethane for the transport sector (International Energy Agency 2020).

2.8. Potential for biogas

Globally, there is an increasing potential for the use of bioenergy. Ten percent of the world's energy demand comes from bioenergy. The energy comes in a liquid, solid and gaseous state ; the most used bioenergy is solid biomass (International Energy Agency 2020). However in the development of sustainable electricity systems, bioenergy was second to solar (Ahmad & Tahar 2014). The future of the biogas industry cannot be undermined. This is because there has been changes in dietary habits to consumption of more meat resulting from urbanization and increase in income. This will lead to the increase of animal manure with an average of 2.5% per annum, it brings about the availability of feedstock and affects the potentials of biogas positively. The availability of feedstock for biogas production is presumed to increase by 40% over time to the year 2040. Every part of the world can significantly produce biogas, but its biggest opportunities can substantially be found across the Asia Pacific region, and other possibilities in Africa, America, and Europe too. In contrast, these potential opportunities can only be made a reality through policies that encourages its use and production (International Energy Agency 2020). Governments must use policies and other mechanisms to encourage the separation and collection of food waste within cities, rural communities and among big business to be used for available anaerobic

digesters for biogas production (World Biogas Association 2019). The technology comes with several benefits. Biogas can be used to produce biomethane through upgrading and purification. Biomethane can be used as transport fuel and should be encouraged by governments (World Biogas Association 2019). Both can lead to resource efficiency, build-up of circular economy and energy security benefits (International Energy Agency 2020). It can also be used to produce biochemicals and bioplastics (World Biogas Association 2019). Biogas can serve as a revenue generating tool for economic development when it is connected to the international carbon market (Gu et al. 2016) and its by-products are sold (International Energy Agency 2020).

By reviewing the biogas situation in developing and developed economies of several countries, Nevzorova & Kutcherov (2019), identified infrastructure as the major barrier affecting the biogas industry. Furthermore, IRENA (2019), also discovered that technical, economic, environmental, institutional, market access, and political issues were prevailing obstacles for biogas development; sociocultural barriers also existed (Qu et al. 2013). Biogas has great energy generation potentials in Vietnam (Shem et al. 2019a). Within the country, major impediment to the potentials of biogas adoption and promotion is the issue of cost, information flow (Wesseler 2010; Bond & Templeton 2011; Qu et al. 2013), and maintenance of biodigesters (International Energy Agency 2020) . However, Wesseler (2010), identified that sociocultural constraints in biogas projects and programs in Vietnam are less prevalent. The barrier of cost is partially due to operation and the price on instruments. The rapid adoption of biogas in China was due to an enormous investment (covering 82%) of the government in the construction of household biogas digesters (Zhang & Wang 2014). Information challenges is due to the large size of the country. This does not permit the easily flow of information on the potentials of biogas. The television and radio programs, word of mouth, engineers and entrepreneurs in the field were the key agents of spreading information on the use and potentials of biogas to rural communities in the country**.** Problem of information flow on the use of the technology was that most farmers do not know how to improve their biogas utilization. The potentials for biogas adoption may be diminishing over time. Although this situation prevails, the application of bioenergy would still be irreplaceable in the future. The two main factors that can help develop biogas potentials are policy and technology advancement (Gao et al. 2019). Even though the technology has existed in Vietnam for more than three decades, there is only limited number of

biogas plants constructed (Nguyen 2011; Nguyễn Võ Châu Ngân et al. 2012; Roubik & Mazancova 2016). Rich farmers are likely to neglect the use of biogas digesters because the opportunity cost for labour is higher for them, the technology is likely to be easily accepted by upper and middle income farmers (Fan et al. 2011; Wang et al. 2016). Agricultural house households and people who own their own houses are likely to adopt the biogas technology, however, small holder farmers with less ha of lands are less likely to adopt it because they cannot produce enough waste to feed the biogas plant (Mottaleb & Rahut 2019). Government and private sector partnership, community grants and subsidy programs, government-backed investment plans can help reduce some of the barriers associated with adoption of the technology (International Energy Agency 2020). Also, policy instruments like low interest rates and grants can be used to increase the potentials for biogas adoption and utilization. There should be a biogas market that deals with biogas appliances and installation materials which can lead to the development of a local and international market niche within the country and eventually increase the number of biogas users (Wesseler 2010). Installation of household biogas systems can be encouraged using economic instruments and there should be a biogas network and management offices across the country; it would help facilitate processes for farmers. Wesseler (2010), brought up an idea that, untreated livestock waste into the environment should be charged an environmental fee (tax). This would help livestock producers to adopt biogas as a waste treatment mechanize and thus evade environmental fee while simultaneously protecting the environment. For biogas potentials to be fully realized it highly depends on regulatory and policy support. Policy makers considers biogas more expensive when compared to fossil fuel. To create a level playing field between biogas and fossil fuels, fossil fuel subsidies must be removed (World Biogas Association 2019).

2.9. Biogas and rural development

Biogas technology supports sustainable development by reducing poverty among rural households and provide energy to remote areas with no energy infrastructure. Rural households basically depend on biomass (firewood) as a source of energy for cooking. A larger percentage of rural communities in the world lack access

to clean energy for cooking. Globally, 2.5 million people died from causes relating to the use of polluted cooking stove and 3 million deaths from outdoor air pollution in 2018 (International Energy Agency 2020). In India, indoor pollution has reduces productive life by 5% (Rohra & Taneja 2016). The adoption of small-scale biogas plants by rural households reduces indoor air pollution (Abadi et al. 2017). It can help rural communities meet their energy needs as well as provide them with a sustainable and healthy life (Singh & Sooch 2004). The provision of household biogas digesters is a good way to support rural development. The technology has been used to provide clean cooking for rural communities in Asia and Africa since the 1980s (International Energy Agency 2020). Biogas digester in rural areas can have positive economic benefits over their lifespan. In China, it was discovered that, rural households produces the largest amount of total biogas within the country (Gu et al. 2016). Lack of loan opportunities, governmental support, underdeveloped rural economy, and high financial requirements can impede on the ability of rural communities to fully utilize the potentials of renewable energies like biogas. Also, although the technology encourages sustainable rural development, some biogas programs may not be aimed at such targets. For instance, in India, implemented biogas technology was unaffordable for a lot of rural households. This was due to the high cost of small-scale biogas plants and small number of livestock; a lot of them were also left out from the benefits of the new technology and government subsidies (Katuwal & Bohara 2009). In Vietnam, there has been a major change in rural setting due to rapid urbanization and economic growth across the country and this has impacted on small-scale biogas production (Vu et al. 2015). Biogas systems in rural household's face labour constraints associated with large volumes of slurry and input water. However, this problem can be solved through the design of an integrated biogas systems within the community (Tucho et al. 2016). Another constraint with the technology is reducing of building value, biogas systems can impact rural building prices. In United States of America, it was identified that rural buildings value declines as big biogas facilities gets closer and increases with small-scale biogas plants(Lee et al. 2017). Zemo et al. (2019), suggest that policy makers should consider compensations for rural houses close to large biogas plants since it can pose a threat their wellbeing. To facilitate the construction of numerous biogas systems in rural communities, there would be the need for a good policy support and biogas programs

should have specific targets, most especially they should be targeted at rural communities with poor energy and financial structure.

3. Aims of the Thesis

The aim of this thesis is to identify existing biogas policy issues in Vietnam and assess how these policy issues affects small-scale biogas plants. The results of this thesis should help policy makers and stakeholders in the biogas industry to make policy reforms and take informed decisions that can positively increase the continuous adoption and fulfil potential of small-scale biogas plants within the country.

Therefore, the following specific objectives were established:

- Identification and assessment of the stakeholders involved its implementation
- Identifying how projects and programmes on small-scale biogas technology were formulated and implemented
- An analysis of its conformity with international policy on renewable energies
- Assessing the impact of policies on small-scale biogas plants
- Identifying bottlenecks in the implemented policy and possible amendments

4. Methodology

4.1. Study area

The study was carried out in Vietnam. The country has a total population of 96 million with a total household of 26,870,079 (UNFPA Vietnam 2019). With a total coastline of 3,444km and a total land area of 331,230 km², Vietnam is the 18th largest country in Asia ("Vietnam: country data and statistics" n.d.). Figure 1 shows its geographical boundaries and the division of its province. Majority of the population work in the agricultural sector. As of the year 2019, 37.2% of the population worked in the agricultural sector, 35.34% in the service sector and 27.44% in the industry sector (General Statistics 2019). The livestock sector is one of the fastest growing sector within agriculture (Vietnam Government 2020). Hanoi, its capital, is among the highest producers of livestock within the country (Huong et al. 2020). Furthermore, pig production and poultry are practiced intensively within all the six agroecological zones of the country. Red River Delta and Mekong River Delta are one of the province with the highest pig concentration (Dao et al. 2020).

4.2. Research design

The mixed-method research design would be employed. This method makes use of both qualitative and quantitative data. It is characterized with at least one qualitative and quantitative component (Schoonenboom & Johnson 2017).

4.3. Data collection

The survey relied on data collected from existing literature on renewable energies, biogas production in Vietnam, prospects for continuous biogas usage in Vietnam, and biogas experts involved in small-scale biogas developmental projects in Vietnam and

Asia. A total of twelve experts from different countries who are actively involved in the field of renewable energy and biogas technology in Vietnam were successfully interviewed. Biogas experts from Vietnam's Ministry of Agriculture and Rural Development and National Agricultural Extension, Hue University of Agriculture and Forestry (Vietnam), Czech University of Life Sciences (Prague), Government College University (Faisalabad, Pakistan), Development Worldwide and Technische Universität Berlin-Department of Circular Economy and Recycling Technology (Germany) were snow balled due to the limited number of experts in this field. Background information on interviewed biogas experts is presented in Table 1.

Table 1 List of interviewed respondents

Name of Organization	**Type of Legal Entity**	**Years of Existence**	**Number of representatives**
1. Technische Universität Berlin	Higher Education Institution	20 years and above	Two
2. Vietnam National Agricultural Extension Centre	Ministry	20 years and above	One
3. Development Worldwide	Non-Governmental Organization	20 years and above	One
4. Czech University of Life Sciences, Prague.	Higher Education Institution	20 years and above	Four
5. Government College University Faisalabad	Higher Education Institution	20 years and above	One
6. Hue University of Agriculture and Forestry, Hue University, Vietnam.	Higher Education Institution	20 years and above	Two
7. Vietnam Ministry of Agriculture and Rural Development.	Ministry	20 years and above	One

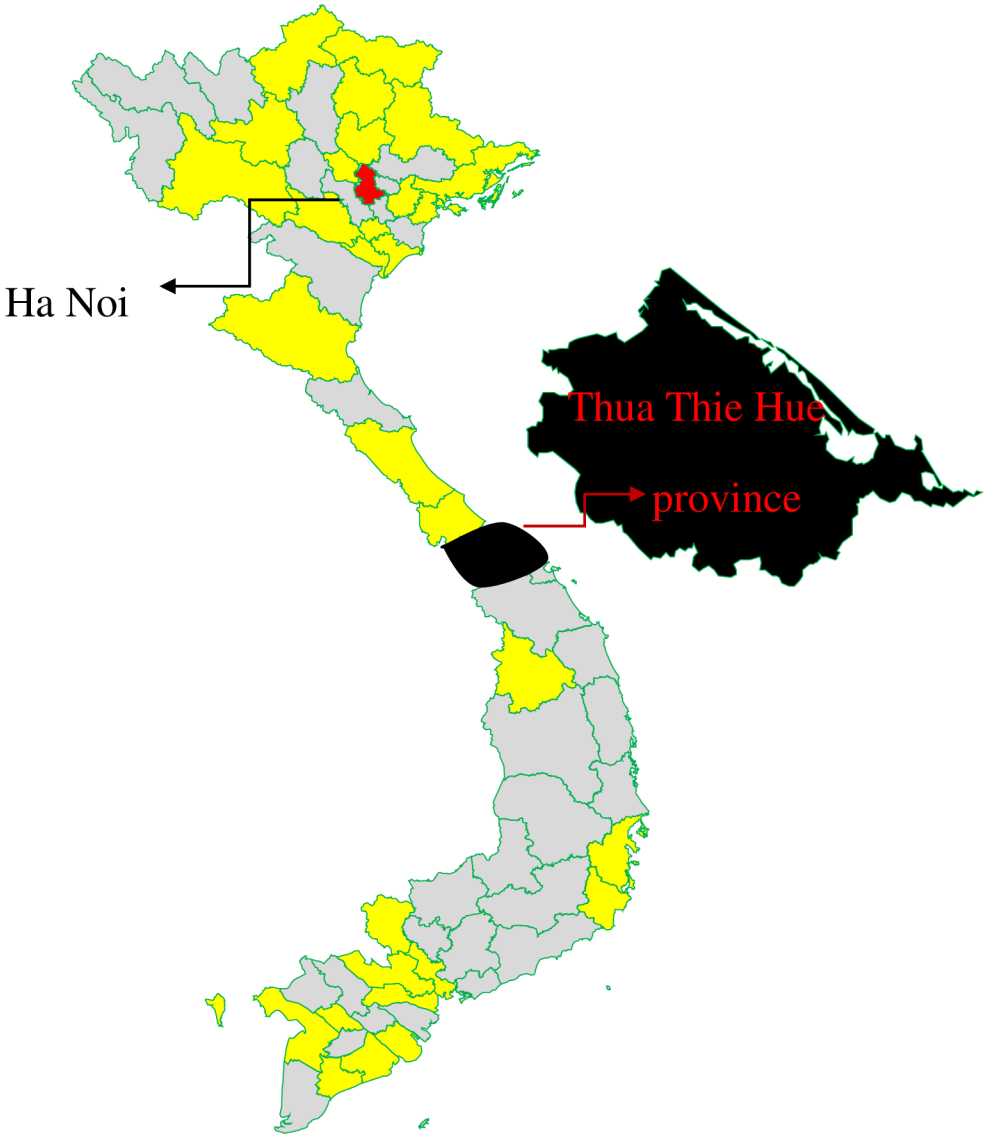

Figure 1 Map of Vietnam

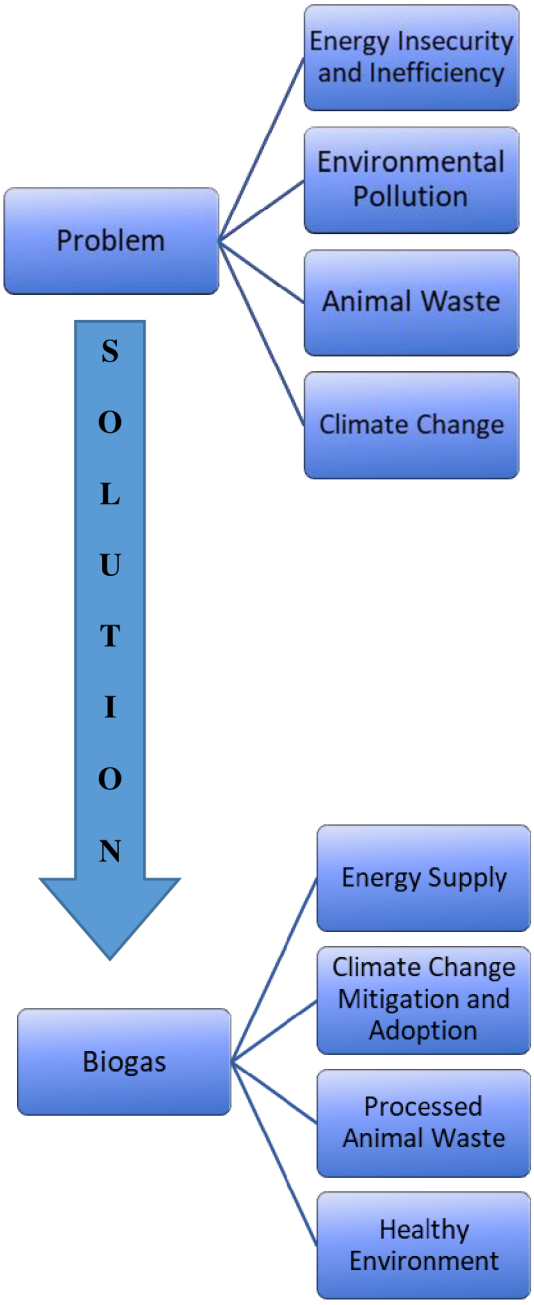

Figure 2 Biogas as a Strategic Solution to Identified Problem

4.4. Analytical Approach

Vietnam is challenged with energy insecurity and energy inefficiency. Energy needs are mostly met through conventional sources. Looking at figure 2, the country is also facing with animal waste management problems due to its vibrant pig industry. The figure also illustrates that, down the chain , these phenomenon will have a long-term effect on climate change. It further shows how a renewable energy such as biogas can solve these problems simultaneously while ensuring climate change mitigation and adoption, and promoting healthy environments. Figure 2, shows a simplified problem and solution analysis for Vitenam. The policy cycle or process is a tool that can be used to analyse the impact of policy (ETF 2018). It examines each of the various stages involved in the drafting and implementation of a policy. This analytical approach was used to assess how small-scale biogas plants in Vietnam are affected by policy issues. Figure 3 demonstrates the five stages involved in policy implementation and how all the stages work as a whole to make decisions that eventually gives rise to biogas policy issues that may affect small-scale biogas industry of Vietnam.

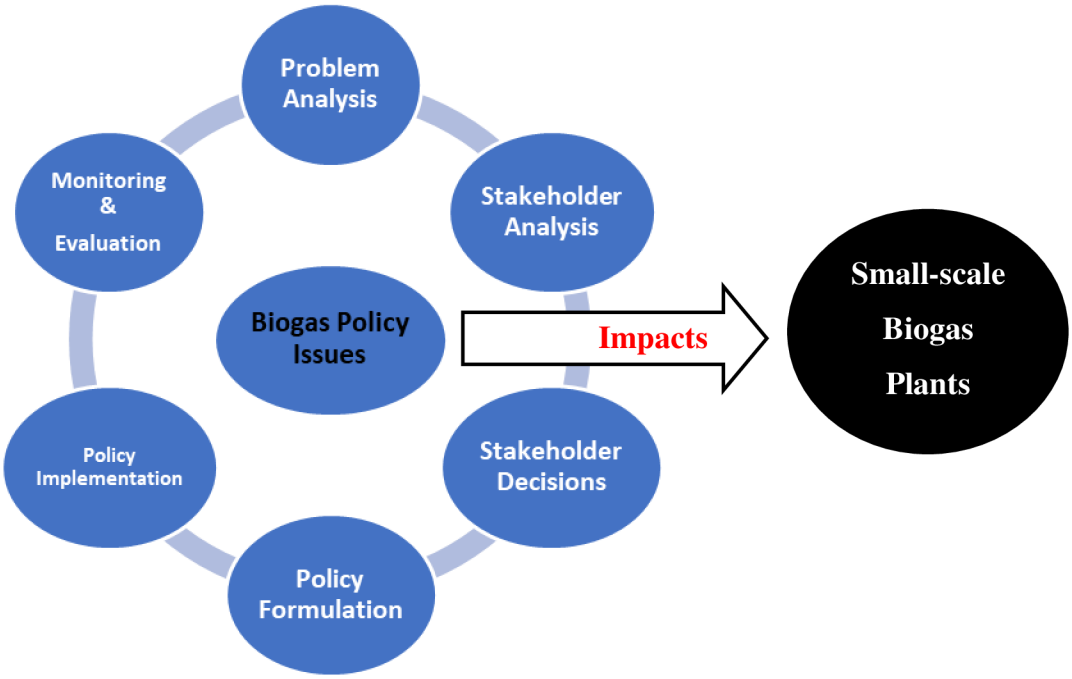

Figure 3 Policy Cycle for Small-scale Biogas Plants

4.5. Data analysis

Descriptive data were analysed using nominal variables and a Likert scale. A five-point Likert scale ranging from very strong, strong, neutral, weak and very weak was used to assess the level of awareness of renewable energy policies within Vietnam among respondents, their level of awareness of biogas policies within Vietnam, respondent's view on the level of conformity of biogas policies in Vietnam with other International Policies on Renewable Energy and how it promotes global biogas usage, respondent's organization's level of participation in biogas policy formulation and implementation within Vietnam, the level of cooperation between respondent's organization and other organizations tasked with biogas policies in Vietnam. Nominal variables were used to assess respondent's knowledge on organic waste management policies within Vietnam, knowledge on the number of implemented biogas programme by respondent's organization, level of support from Vietnam government to implemented biogas programmes by respondent's organization and issues presented by the beneficiaries of the implemented biogas projects to the respondent's organization. Qualitative data was analysed using policy cycle approach and comparison of gathered data to reviewed literature.

4.6. Limitations

Due to the Covid-19 pandemic, it was not possible to collect data directly from the field and thus, data was collected remotely through skype interviews, email correspondence and via google forms. Also, because of the busy schedule of these biogas experts, data was collected over a period of 90 days.

5. Results

From table 4, the results show that, 16.7% of the respondents (experts) had a very strong level of awareness of renewable energy policies within Vietnam, 41.7% of them had a strong level of awareness, 25% were neutral, followed by 8.3% each for weak and very weak. The results also indicated that, through published articles, journals and documents related to renewable energy in Vietnam, all the interviewed respondents had come across some renewable energy policies in Vietnam. The level of interviewed organizations participation in renewable energy policy formulation and implementation in Vietnam came out as strong which represented 41.7%, 25% were neutral, 16.7% represented very weak, 8.3% for both very strong and weak. Respondents also had a strong level of awareness of biogas policies within Vietnam which represented 41.7%, 25% were neutral, 25% were very strong, 8.3% was very weak and non was weak. 50% of the respondents were neutral to how biogas policies within Vietnam were in conformity with existing international policies on renewable energy and its promotion to global biogas usage, 41.7% had a strong view while 8.3% disagreed of the statement. Also, the organizations had a strong level of participation in biogas policy formulation and implementation within Vietnam which represented 33.3% of the results, followed by 25% which were neutral, 16.7% which were very weak and weak and 8.3% which was very strong. There was a strong level (41.7%) of corporation between the interviewed organizations and other organizations involved in and tasked with biogas policies within Vietnam, 25% were weak, whereas 16.7% represented neutral and very strong. In addition to the above, 88.3% had heard of organic waste management policies in Vietnam, while 16.7% of them had not heard of such policies. A larger proportion of respondents were aware of small-scale biogas programs implemented by their organization which stood at 91.7% while 8.3% were not. 58.3% of the respondents agreed to the statement that their organization received some form of support from the Vietnam government while undertaking their biogas programs within the country while 41.7% disagreed with the statement. There was also a neutral stance on whether the beneficiaries of the implemented biogas programs confronted implementing organization with problems relating to biogas production and usage. The results, also presented in table 2 showed that, 50% of the organizations were confronted with some form of biogas issues by benefactors while the other 50% were not. 66.6% of the

organizations made changes to implemented biogas programs to address arising biogas issues, the rest made no changes. Majority of the respondents which represent 41.7% are of the view that, the government and other stakeholders' response to arising biogas issues within Vietnam has not been sufficient, 33.3% were against this statement while 25% did not have any strong opinion on this statement and thus were neutral. Also, 66.6% were of the view that, the government of Vietnam together with other stakeholders have the sufficient capacity to enact policies and implement programs that would enable the continuous use of biogas (most especially small-scale biogas plants) within the country, 16.7% disagreed with statement and 16.7% of them were neutral to the statement.

Table 2 Descriptive Statistics on Implemented Small-Scale Biogas Programmes and Projects in Vietnam (N=12)

	Response (%)		
Statement	**Yes**	**No**	**No strong opinion**
1. Knowledge on organic waste management policies in Vietnam	88.3	16.7	0
2. Awareness of small-scale biogas projects and programmes implemented in Vietnam	91.7	8.3	0
3. Did implemented biogas projects and programmes implemented by your organization receive any form of support from the Vietnam government?	58.3	41.7	0
4. Did the beneficiaries of the implemented biogas program(s) in Vietnam confronted your organization with issues pertaining to biogas production and usage?	50	50	0
5. Was your organization able to make changes in the implemented program that addresses arising biogas issues?	66.4	33.6	0
6. Has the government and other stakeholders' response to arising biogas policy issues within Vietnam been sufficient?	33.3	41.7	25
7. Do you think the government of Vietnam together with other stakeholders have the sufficient capacity to enact policies and implement programs that would enable the continuous use of biogas (most especially small-scale biogas plants) within the country?	66.6	16.7	16.7

5.1. Policy Analysis Using the Policy Cycle Approach

Public policies are course of actions instituted by governments, nevertheless, they must be in the best interest of citizens (WWF 2018). While policy analysis is the systematic evaluation of implemented policies to make way for improvements and new sound policies. Policy analysis erupted after the second world war to tackle water resource problems and improve health polices, however, in recent times, its wings has spread to several public sectors (ETF 2018). Policy cycle or policy process follows up by assessing how a stakeholders or a change in power can influence the implementation of policies (ETF 2018; WWF 2018). The process of the policy cycle approach cuts across five stages (Bardach & Patashnik 2015; ETF 2018; WWF 2018). For this study, the keen interest is an ex-post analysis of policies by focusing on stakeholders who are into small-scale biogas plants in Vietnam and thus only four stages of the cycle was focused using ETF (2018) guide to policy analyses. The first to the third stage of the cycle would be elaborated in this chapter and the final stage would be elaborated in the prospects and recommendation subchapter of this study. The first process in the policy cycle or process approach is identifying the problem. As clarified extensively in the introduction and literature review, Vietnam's problem was organic waste from a vibrant livestock industry and energy inefficiencies. Vietnam is among the top countries that is into the production and consumption of livestock, most especially pigs. Pig production is among the 32 major greenhouse gas emission sources in Vietnam (Dao et al. 2020). The second step is to identify possible solution (ETF 2018; WWF 2018), thus, the government of Vietnam instituted the policy known as "The National Biogas Program" ("Vietnam Biogas Programme | SNV World" n.d.) and other environmental protection and energy policies (Minh Do & Sharma 2011; Minister 2018a) . Besides the Vietnam National Biogas Program, Table 3 illustrates some key policy interventions by government to help tackle this phenomenon. In conjunction, these policies have led to the promotion of energy supply, energy efficiency, renewable energy promotion and development, environmental protection, and climate change mitigation strategies. Elaborating more on policies on biogas, the Vietnam National biogas programme was established through a deliberate collaboration between the Netherlands Development Organization and Vietnam's Ministry of Agriculture to create a viable biogas market (Sectors 2014), and also provided households and farms the opportunity to manage their

organic waste while generating biogas for cooking. The third stage is interpreting the outcomes using the evidence at hand. There was a solid confirmation that, interviewed stakeholders were aware of several renewable energy policies in Vietnam but the most dominant one was the Vietnam National Biogas Programme. The outcome of these policies had both positive and negative impacts. To begin with the positive side, policies focusing on renewable energies and biogas to be precise has really been beneficial to the people of Vietnam, respondents indicated also that most of these policies successfully achieved their stated goals. The results from this study showed that, policies like the Vietnam National Biogas Programme has sprouted interests in lots of international organizations with a focus on climate change and rural development to undertake several biogas projects in Vietnam; justifies the augment that international organizations play a big role Vietnam's policy implementation (Shem et al. 2019b). Millions of small-scale biogas plants have been installed across the country by international organizations and non-governmental organizations (Dao et al. 2020). This has also increased the value chain of biogas in Vietnam and created jobs for masons around the country. Even though the programme received several emission certificates and reached its goals (Sectors 2014), it also faced some setbacks. The study found out that, due to the problems with co-financing and feed-in-tariffs enjoyed by only a few, there was rapid build-up of low-tech biogas plants within the small-scale biogas market of Vietnam. Also, energy policies that reduced the price of conventional fuels made technologies like biogas more expensive among the people. These assertions confirms the arguments made by Nesta et al. (2014) and Pitelis et al.(2020) that, each policy instrument affects renewable energy differently. It further affirmed that low electricity prices and subsides on fossil fuels make renewable energy technologies less competitive (Sectors 2014).

From our results, it was clear that many biogas projects in Vietnam were unsuccessful without subsidies from the government and funding; this affirmed that, biogas projects were unprofitable without subsidies (Wang et al. 2016). Also, some projects under the Vietnam National Biogas Programme presented too ambitious outcomes to the project beneficiaries, and this brought about a lot of setbacks in project participation for subsequent years. Besides the Vietnam National Biogas Programme, evidence from our results indicated that, programmes under renewable energy policies have not fully been able to change the mindset of the locals towards the transition to a circular economy. It further showed that several policies within Vietnam lacked

regulations that checks for compliance with the law. This supports the arguments made by Wesseler (2010) that, environmental laws in Vietnam are not treated with much importance. From our results, the study is in the same point of view with Shem et al. (2019) on the unavailability of adequate baseline data for evaluating some implemented policies for further reform.

Table 3 Summary of Key Energy Policies in Vietnam

Policy	Summary
1. The National Energy Development Strategy	To increase the share of renewable energy to total energy supply to 11% by the year 2050
2. Vietnam Power Development Plant VII (PDP 7)	This is to supplement the Vietnam's National Energy Development Strategy to 2030 and outlook to 2045
3. Decree on Energy Conservation and Energy Use	Provided subsides for capital investment for renewable technologies, preferential tariffs for renewable energy products and loans
4. Environmental Protection Law	Protecting the environment while ensuring the use of clean energy
5. Green Growth Strategy	Focused on reducing climate Change
6. Vietnam National Biogas Programme	Focused on organic waste management, provide clean energy, and develop a viable biogas market
7. National Climate Change Strategy	Focused on climate change mitigation and adoption strategies
8. The Paris Agreement	Focused on climate change and renewable energies
9. Biomass Energy Development and Utilisation policy	Focused on renewable energies
10. Biofuel Blending Mandate	Focused on renewable energies and energy efficiency

5.2. Policy coherence

Policy coherence is when policy instruments and other policy goals are in consistency with one another (Beck et al. 2009; Engel et al. 2013; Brooks 2014). The analysis of policy coherence is to find out the inconsistency in implemented policies (Huttunen et al. 2014). A country's policy coherence can also be measured. King et al. (2012), identified that Internal coherence, intra-governmental coherence, inter-governmental coherence were the three main stages for measuring policy coherence among developed countries. When there is no coordination among policies, the sustainable transition of innovations are likely to be a failure (Weber & Rohracher 2012). For a successful transition of technologies like biogas, there is the need for policies that cuts across several sectors (Wilkinson 2011; Lybæk et al. 2013). The study did not make any assessment of internal coherence; however, a slight assessment of external coherence was carried out. The study tried to infer from the respondent's point of view, the level of coherence between policies in Vietnam that promotes biogas production and other international policies that promote the production and use of biogas. The results which can be found on table 4 turned out to be neutral. Majority of the respondents had not come across some of ISO's standards on biogas production and use. The interview revealed that half of the interviewees were also not exposed to other international policies on biogas. The International organization for standardization has developed several international standards on biogas such as the "ISO 20675:2018" which provides guidelines that facilitates international trade on biogas installation and cooperation, helps curtail technical barriers, and contributes to the development of regional and national regulations on biogas production and application. It is very prudent for biogas experts in Vietnam to be frequently abreast with such international standards to help in the rapid development of the technology.

Table 4 Descriptive Statistics on Renewable Energy Policies in Vietnam (N=12)

	Level of Response (%)				
Statement	**Very Strong**	**Strong**	**Neutral**	**Weak**	**Very Weak**
1. Level of awareness on renewable energy policies in Vietnam	16.7	41.7	25	8.3	8.3
2. Level of participation in renewable energy policies formulation and implementation in Vietnam	8.3	41.7	25	8.3	16.7
3. Level of awareness on biogas policies in Vietnam	25	41.7	25	0	8.3
4. Level of conformity of biogas polices in Vietnam with existing international laws and its promotion to global biogas usage	0	41.7	50	8.3	0
5. Level of participation in biogas policy formulation and implementation within Vietnam	8.3	33.3	25	16.7	16.7
6. Level of cooperation between the organization and other organizations tasked with biogas policies within Vietnam	16.7	41.7	16.7	25	0

5.3. Biogas Value chain

The biogas sector in Vietnam is partially market based, many masons can offer their building biogas digesters in the open market. The technology has also opened doors for rapid investment in the country. According to a report from the International Biogas Workshop on Small and Medium Scale Biogas on November 2013 in Hanoi, the Asian development has signed a financial support agreement with Vietnam to implement projects focusing on project management, credit for biogas value chain, technology transfer in agricultural waste management practices and livestock waste management (Sectors 2014). More laws and new policies must be developed to further develop the biogas value chain of Vietnam. Even though the government of Vietnam yearns for a public private sector partnership within the biogas sector, they have mix reactions on how to go about it because of their less experiences in such partnerships. The lack of public private partnership has also been linked to policy development and conflict of interest (Sectors 2014). However, for biogas markets to be attractive to international investors, it must be fully developed. For this market development to take place, there must be an identification of the type biogas plants that would be suitable for the market (small, medium, large and industrial scale), the availability of experienced construction and maintenance teams, potentials for private sector investment, access to digester inputs and finally biogas demand and supply mechanisms (Wesseler 2010). There is still less awareness on opportunities offered by the technology and access to information on biogas technology within the Vietnam biogas market, it is yet to reach its maximum point. Government must ensure that, its policies promote good economic and environmental outcomes.

6. Discussion

The most common renewable energy policy known by interviewed experts was the Vietnam National Biogas Programme. Others had also heard of the Master Plan to increase renewable energy in Vietnam, the Vietnam Power Development Plant VII (PDP 7), the Green Growth Action Plan and Decision number 2068/QĐ-TTg by Vietnam Government in 2015 year about Strategy of development renewable in Vietnam by the year 2030 to 2050. The results also indicated that respondents were aware of waste management policies in Vietnam that compelled farms, most especially bigger ones to treat their wastewater, however, there was no obligation for them to use it for biogas production. Vietnam's Ministry of Agriculture and Rural Development also stated that, in relation to organic waste management policies, since 1994, the Ministry of Natural Resources and Environment has passed several environmental protection laws with sub sections that focuses on organic waste management within the country. Biogas experts from Hue University of Agriculture and Forestry of Vietnam also pronounced decree number 38/15 and direction number 41/CT/TTg by the government as policy strategies that promotes organic waste management. In the quest to contribute to renewable energy usage and biogas policies in Vietnam, the Technische Universität of Berlin (Department of Circular Economy and Recycling Technology) together with Herbst Umwelt Technik GmbH (department of environmental engineering) undertook several biogas projects in Vietnam. Since 2016, they have launch three biogas projects in Vietnam which included the BioRist Project (2016-2019), it focused on a technological process for producing biogas from rice straw. Between the years 2017 and 2018, they launched another project known as the UKAVita project. The project was carried out in Mekong Delta to help assess the problems of mid and small-scale biogas plants and find possible solutions. PICO Absorber project (2019 - 2021) was also lunched by them for the development of an external filter for small-scale biogas plants in Vietnam that removes Hydrogen sulphide (H2s) from the biogas produced. They contributed to biogas policies by organizing stakeholder workshops on how to improve biogas technology in Vietnam and cooperating with GIZ Vietnam on how to promote the share of biomass energy in Vietnam. Vietnam's Ministry for Agriculture and Rural development had contributed enormously to biogas polices in Vietnam by coordinating and managing the activities of the Vietnam National Biogas programme. Hue University of Agriculture and Forestry

also contributed to biogas policies in Vietnam by undertaking several research for policy development in Vietnam. In the Hue province, biogas experts from the Czech University of Life Sciences Prague in collaboration with Czech Development Cooperation has installed 700 small-scale biogas plants and has provided capacity building for more than 800 small-scale biogas users within the province, since 2010, they have also organized other technological projects, supplemental workshops and projects which were in coherence with the Vietnam National Biogas Programme. They continued to contribute to biogas usage and biogas policies in Vietnam by undertaking several scientific research on biogas technology for the local authorities, publications and partaking in national biogas projects. The results also showed that, the National Agricultural Extension Centre of Vietnam contributes its quota by using results from increased production through farmer deployment to propose policies that encourage biogas usage while reducing environmental pollution, they also organized biogas projects, forums, and seminars. Non-governmental organizations such as Development Worldwide also undertook renewable energy projects which included biogas within the rural areas of the Thua Thien Province from the year 2011 to 2013. Some of the key things considered by the institutions while drafting their biogas projects and programmes were, economic situation of the target area, number of beneficiaries and household size, sources of energy, prices of other conventional fuels, the number of small-scale biogas plants within the country and how best to improve their efficiency, environmental pollution and organic waste management, availability of feed stock, number of farm animals, demand for digestate, awareness and education on green energy, expert advice on biogas from within and outside Vietnam, funding and donor's request based on the Vietnam National Biogas Programme and many more. While implementing these projects and programmes, the institutions received supports such as, project funding and co-financing, research allowance, agricultural maps, agreements with local authorities, facilitation of project implementation, sensitization and mobilization within target area, networking, and information support from the government of Vietnam. In the process of implementing these projects and programmes, the institutions were also faced with some obstacles. Some of the institutions faced problems in getting grants for follow up projects after successful pilot projects. Getting baseline data for implementation of new and subsequent projects was also difficult since most respondents within targeted area were unwilling to be interviewed, and some of the developed biogas models were

unsuccessful. Biogas experts from Technische Universität Berlin who were working on rice straw for biogas production indicated that, the current policy framework within Vietnam makes rice straw biogas plants economically inviable and thus made project implementation difficult. Also, one major problem that was brought up by most of the interviewed biogas experts was the mindset of the people. Because change occurs gradually and due to lack of sufficient awareness, most of the natives of targeted areas found it difficult to understand why they are to use manure for cooking. Another problem identified by these biogas experts which they considered to be one of the factors reducing the wide acceptance and use of small-scale biogas plants in Vietnam was low electricity prices and thus, this hindered the economic viability of small-scale biogas plants. Additionally, there were problems with sustainability and project ownership, the people relied only on donor subsidies and were not interested in investing in their own development and maintenance of the technology. The beneficiaries of these projects and programs also confronted the implementing institutions with some important issues on technical difficulties with operation and management of the biogas plants, problems with financing of own biogas plants, and low project output and outcomes than they expected. After being confronted with these issues, most of the implementing institutions made some adjustments to their projects. Development Worldwide, improvised into its project, the supply of pigs to its targets when they recognized that most of the local household did not have enough pigs to produce enough manure to make their small-scale biogas plants function efficiently. Czech University of Life Sciences Prague in collaboration the Czech Development Agency also asked its beneficiaries for less co-financing of its small-scale biogas projects, and this made more of its beneficiaries, most especially rural farmers to have access to small-scale biogas plants as compared to the Vietnam National Biogas Programme. In addition to the above, the Vietnam National Agricultural Extension Centre increased training and awareness for farmers and small-scale biogas users to enable them solve issues related to technical difficulties, and proper handling and maintenance issues presented to them during project implementation. The results also indicated that, all the biogas expects interviewed in this survey are of the view that the use and sustainability of small-scale biogas plants in Vietnam is largely reliant of viable policies. They emphasised that, policies that focuses on regular safety checks of small-scale biogas plants can help weed out low-tech biogas plants that creates a bad

impression on the entire biogas sector of Vietnam. Also, they indicated that, if implemented policies creates programmes that creates awareness and simultaneously makes the treatment of on organic waste compulsory to farmers through proper regulatory checks back by the law, it can lead to the increased use and sustainability of biogas technology and renewable energy technology in general within the country. They were also of the view that, policies like the Vietnam National Biogas Program played a big role in the use of small-scale biogas and more of such policies should be encourage. Finally, the results showed that, the factors hindering the continuous development of the small-scale biogas sector in Vietnam through policy development, amendment and implementation were, the influx of low-tech small-scale biogas plants, a shift from small-scale animal husbandry to large-scale may lead to the possible implementation of policies that would encourage mid and large-scale biogas production rather than small-scale (the government may use this to increase feed-in tariffs for business generating their own electricity from biogas), lack of cross-sectional cooperation, policies on cost of conventional fuels, emission trading policies limiting the potentials of renewable energy use, husbandry diseases such as the African swine flu has caused lots of local households to keep few pigs or no pigs at all and thus the use of small-scale biogas plants by such households becomes irrelevant, non-enforcement of the law in terms of waste manage regulations, lack of transparency, economic, social and technical barriers.

By connecting each of the steps in the analytical process (ETF 2018) to create a meaningful narrative, the analytical approach has provided the evidence that, biogas has only been a successful renewable energy technology in Vietnam through policy implementation and not through any other means. The analytical approach also provided evidence which corresponded to findings on biogas from other researchers within the region of study. The first stage of the policy cycle analysis, helped to identify the stakeholders involved in biogas policies and its implementation in Vietnam. Although stakeholders from big government institutions like Vietnam Ministry of Agriculture and Rural Development, Vietnam National Agricultural Extension Centre, and other local and international institutions plays an active role in biogas policy formulation and implementation, there was no evidence that beneficiaries of small-scale biogas plants, most especially those from the rural communities are actively involved in the decision process. Besides the government of Vietnam, the stakeholder with the highest stake in small-scale biogas policy implementation for rapid technological

transition was the Dutch Development Organization (SNV). The second stage of the analytical approach provided evidence on the how the identified stakeholders formulated and implemented programmes and projects to address the problem identification of the first stage of the policy cycle. Although the identified problem at the first stage of the analysis was organic waste management and energy inefficiencies, a much broader picture was to reduce the impact of climate change. Thus, several policies on climate change mitigation and adaptation were instituted before the inception of biogas policies like the Vietnam National Biogas Programme. Some of these policies are the Environmental Protection Law, Green Growth Strategy, National Climate Change Strategy, and the Paris Agreement which can be found at table 3. Except for hydropower, several of these polices were formulated to implement projects and programmes that facilitates the use of renewable energies like biogas. Examples of such policies are the National Energy Development Strategy and the National Master Plan for Power Development, which aims to increase the output of renewable energies to total energy supply and reduce the use of fossil fuels. Linking the above to the second specific objective of this study proves that majority of implemented small-scale biogas programmes and projects were formulated not to only supply rural households with energy and organic waste treatment strategies but rather, to tackle climate change as a global pressing need.

The International Organization for Standardization defines conformity assessment as the ability to meet the specific requirements to produce a particular product. Even though one of policy issues faced by Vietnam is the infiltration of low-tech biogas plant, from my point of view, Vietnam meets the conformity assessment of International Organization for Standardization for production of biogas under anaerobic digestion. Over the past decades, they have successfully installed thousands of small-scale biogas plants, nevertheless, they are not yet technologically advanced to upgrade biogas to biomethane. Also, in other countries where bioenergy is in competition with arable lands for food production to produce energy, such conflicts does not exist in Vietnam, majority of the digesters are feed with animal waste. In contrast, the locals are now discovering the potential use of residues for biogas generation instead of solely relying on animal waste. Further interpretation of findings revealed that a major issue that may affect small-scale biogas plants in the future is its potential viability when medium and large-scale biogas plants become more dominant. The government of

Vietnam and other major stakeholders like big international organizations may provide massive financial and technical support through policy amendments to big industries and companies who are ready to make a shift from the use of fossil fuels to biogas. This is because such companies produce the highest quota to carbon dioxide emissions. As the policy cycle has previously revealed climate change as the ultimate motive behind biogas policies in Vietnam, more attention should be paid to the highest contributors to carbon dioxide emission rather than the low contributors, and this puts the viability small-scale biogas plants at a disadvantage. Policies that solely promotes support for medium and large-scale biogas installations will lead to the gradual fade out small-scale biogas plants. In addition, a policy instrument like taxation and subsidies can pose as a serious policy issue for small-scale biogas plants in Vietnam. Tax instruments discourages the development of renewable energies (Liu et al. 2019; Shem et al. 2019), while subsidies for fossil fuels makes renewable energies like biogas more expensive (World Biogas Association 2019; Wang et al. 2016). Subsidies often coming as a form of government support is a major element that ensures the financial stability of small-scale biogas plants. There are no coherences between these policy instruments when comparing fossil fuels to renewable energies. To make biogas more attractive than fossil fuels, more government grants and subsidies should be placed on renewable energies while higher taxes should be imposed on the use of fossil fuels. This would increase the value chain for biogas production within the country and will also create incentives for more international cooperation and rapid adoption of the technology. The biogas value chain of Vietnam can be more viable and profitable if more attention is given to the small-scale biogas industry by creating favourable policies that protect infant biogas companies from large-scale giant biogas companies. This is because Vietnam is a lower middle-income country and thus majority of the population cannot afford the services if medium-large scale biogas companies.

6.1. Prospects and Recommendation

New policies are hardly developed, nevertheless, they rather erupt from existing policies through policy analysis and reformation of policy instruments to better suit new policy goals (Kern & Howlett 2009). The final stage of the policy cycle approach is to formulate recommendations based on the findings. Policy recommendation helps to suggestion alternatives for decision makers and serves as a template for policy decisions (ETF 2018). As the livestock industry in Vietnam is shifting from a small-scale industry to a large-scale industry, the biogas industry is as well shifting gradually from small-scale to industrial production. There should be policy support for the small-scale biogas industry of Vietnam to prevent it from fading out when the shift gradually reaches its peak. Also, since the biogas industry of Vietnam is partially market based, the government must develop policies that protects the small-scale biogas industry from the penetration of inferior biogas technologies. Besides achieving the theory of change, small-scale biogas projects in Vietnam should aim at transforming beneficiaries to invest in their own sustainable livelihood rather than being reliant. New policies on renewable energies should categorically state the share of specific renewable energies to be developed. Its projects and programmes should also state the targets for each renewable energy in the attainment of the sustainable development goal on affordable and clean energy, and climate change mitigation and adaptation. Renewable energy policies should not solely focus on energy production; however, renewable energy policies and environmental protection policies should have harmonized rules and regulations that aims at reducing climate change. Policy makers should enact similar standards and principles when drafting small-scale to large-scale biogas projects and programmes. Due to the resource requirements in achieving some policy goals, policy makers should be wary not to substitute policies that require higher government expenditure to those that can easily be undertaken by the private sector. For instance, policies focusing on small-scale biogas plants for rural development should not be substituted for partnership projects in the private sector for medium to large-scale biogas plants. Both programmes and projects should be treated with equal priority.

Furthermore, small-scale biogas users, most especially those benefiting from biogas programmes and projects through policy implementation should invest more in the maintenance of their plants to ensure its sustainability. The practice of maintenance

culture for small-scale biogas plants provides an assurance for investment security. In the long run, such invest will ensure the continuity of the technology among smallholder farmers and households and help project goals and objectives to reach full capacity. On both national and regional level, attention should be given to knowledge transfer and raising awareness regarding the available benefits of biogas production and usage, especially as the current biogas market is still immature. The people will be willing to invest more into the technology when they are aware that besides the use of biogas for heating, cooking and electrification, biogas can also help them have fair and stable climate for agricultural production through climate change mitigation and adaptation. To add to the above, since Vietnam is a developing country with lower middle income, making biogas technology popular at the local level is very important for the rapid diffusion and sustainability of the technology. As a national strategy, the government can help majority of the households to upgrade their sewage systems and manholes through small-scale biogas plants. The government can draft policies that may mandate commercial farms to install biogas systems as their waste treatment plants. Also, in Vietnam, majority of small-scale biogas users are reliant solely on animal manure, as new technologies in biogas production are emerging, there is the need for massive education on the use of other forms of input like plant materials and green waste. This can help those with low feed-in stock meet their average input requirements for their digester. Globally, through the sustainable development goals, every country is aiming at producing affordable and clean energy by 2030. This has placed a higher value on primitive technologies like biogas within the energy sector. Vietnam must take advantage of this opportunity by expanding its biogas value chain through technological advancement, market expansion, research, international corporation, and private sector partnership. Finally, except for projects and programmes under the Vietnam National Biogas Programme, there is the need to assess the effectiveness of specific biogas programmes implemented in Vietnam; this can be the basis for further study.

7. Conclusion

Climate change stands as the major element driving the diffusion of biogas technology in Vietnam. Although there has been a strong awareness on the use of biogas among all stakeholders in Vietnam, most locals are yet to understand the importance of biogas technology to climate change and thus, are still in mental captivity about the idea of using manure to cook food. This situation provides evidence that, there is less awareness on the use of plant residues for biogas production among the locals. Projects like the BioRist project and other projects focusing on the use of plant residue for biogas production must be promoted. Also, the infiltration of low-tech biogas plants would further discourage people from using the technology if the benefit cost ratio for the installation of the plant does not look reasonable after a short life span. Good policies have also played a big role in the use of the technology. Policies like the National biogas programme, the Vietnam Power Development Plant VII (PDP 7), the Green Growth Action Plan and the government's decree on organic waste management has impacted positively by increasing the number of small-scale biogas plants installed within the country. Conversely, policies that promotes the use of fossil fuels through the amendment of favourable policy instruments like subsidies for oil and gas puts biogas at a disadvantage. There should be a higher level of coherence between policy instruments for renewable energies and non-renewables. Furthermore, the government must implement policies that protects the small-scale biogas industry from the infiltration of low-tech small-scale biogas plants. As a form of protection, the policies should also state government's quota of contribution small-scale biogas development when compared to the medium-large scale biogas industry. This is to prevent the neglect of the small-scale biogas industry when a drastic shift in needs causes the medium and large-scale biogas industry to take the biggest share of the entire biogas value chain of Vietnam. A higher percentage of government support through policy amendments should be given to the small-scale biogas industry because the technology provides support for smallholder farmers in rural communities who are contributing actively in the quest to feeding the universe by 2050 when global population increases drastically.

International bodies outside Vietnam have contributed enormously to the use of small-scale biogas plants within the country through the implementation of several projects over the past decade. There should be more policies that makes international

cooperation with the local government more favourable for climate change initiatives like biogas nevertheless, the government must also create policies that puts the locals in a position to be interested in investing in their own development through funding.

Funding remains the biggest barrier to biogas policy amendments and implementation. The several biogas programs implemented over the decade could have yielded more positive impact if financial barriers like co-financing by the beneficiaries did not exist. Finally, there should be a system that monitors implemented policies and evaluates the effectiveness of implemented biogas programmes to enable the proposal of new realistic polices on biogas. Stakeholders tasked with biogas issues should also not implement projects with outcomes that are too ambitious to realise, because beneficiaries would be discouraged with such projects if outcomes are not achieved to their satisfaction. More research should be carried out on the impact of specific biogas projects implemented in Vietnam on small-scale biogas plants.

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Appendices 1

Master thesis data collection for "Small-scale Biogas Plants in Vietnam; how are affected by policy issues" from the Faculty of Tropical AgriSciences, Department of Sustainable Technologies of Czech Republic University of Life Sciences Prague.

1. Name of Organization ……
2. What type of legal entity does your organization belong to?
3. How long has your organization been in operation?
4. What is your level of awareness of renewable energy policies within Vietnam?
5. Have you heard of any renewable energy policy in Vietnam?
6. If yes, please mention the renewable energy policy or policies in Vietnam that you have heard of
7. What is the level of your organization's participation in renewable energy policy formulation and implementation within Vietnam?
8. Do you know of any organic waste management policy within Vietnam?
9. If yes, please mention it (or them)
10. What is your level of awareness of biogas policies within Vietnam?
11. Do you think that biogas policies within Vietnam is in conformity with other international polices on renewable use and the promotion of global biogas usage?
12. What is your organization's level of participation in biogas policy formulation and implementation within Vietnam?
13. What has your organization done or is doing to contribute to biogas policies within Vietnam?
14. What is the level of corporation between your organization and other organizations involved and tasked with biogas policies within Vietnam?
15. Has your organization implemented any program(s) in relation to small skill biogas usage in Vietnam?
16. If yes, please state these program(s) and their various year of implementation
17. What was or were the key things taken into consideration while drafting your biogas program(s)?
18. Was your implemented program(s) given any form of support by the Vietnam government?

19. If yes, please mention the form of support received
20. What has been some of the obstacles to your biogas program(s) implemented in Vietnam?
21. What was the cause(s) of these obstacles to your program(s) implemented?
22. Has or did the beneficiaries of the implemented biogas program(s) in Vietnam confront your organization with issues pertaining to biogas production?
23. If yes, what were some of the most salient issues?
24. Was your organization able to make changes in the implemented program to address arising biogas issues?
25. If yes, please state some of the changes made
26. Do you think the government and other stakeholder's response to arising biogas policy issues within Vietnam has been sufficient?
27. Do you think the government of Vietnam together with other stakeholders have the sufficient capacity to enact policies and implement programs that would enable the continuous use of biogas (most especially small-scale biogas plants) within the country?
28. In a nutshell and from your own point of view, how has policies in Vietnam and its related issues impacted on the usage of small-scale biogas plants and the biogas sector as a whole?
29. What do you think are the barriers hindering the continuous development of the small-scale biogas in Vietnam through policy amendment, formulation, and implementation?
30. Please any additional comments in relation to this survey can be written below
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List of the Appendices: Appendix 1 ……. Questionnaire