Masters thesis in Energy transition in Nepal

“The government initiation to Renewable Energy Technologies(RETs) to overcome energy crisis in Nepal”

(The Socio-technical Approach)

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Abstract

The purpose of the thesis is to study and identify the transformative changes and renewable energy technology development by the government of Nepal to overcome the energy crisis in the country. And also, investigate the use of the socio-technical approach in Nepal as the energy transition tool from traditional resources to renewable energy resources to produce the energy to fulfill the basic energy demand for the country and to reduce fuel dependency. The thesis used the descriptive and then exploratory research design and deductive approach to collect data. In order to investigate, the thesis primarily used the socio-technical system framework as energy transition and study innovation as renewable energy technologies(RETs) by collecting qualitative data and analyze them accordingly. It has drawn that the government has initiated renewable energy technologies, however, the various challenges and barriers affecting the implementation of these technologies and the government is unable to produce sufficient energy. To generate the required energy the government needs to maintain the proper interaction and support at various levels with other interested actors who support innovation, just as the MLP model where three levels(the landscape level, the regime level, and the niche level) interact and support each other to enhance the energy transition from traditional to renewable sources.

Keywords: Renewable energy, Renewable Energy Technologies(RETs), the Socio-Technical System, Energy Transition, Social Innovation

ABBREVIATIONS

ADB: Asian Development Bank
AEPC: Alternative Energy Promotion Center
BAT: Best Available TechnologiesDANDIA
BEPA: Bureau of European Policy Advisors
DANIDA: Danish International Development Assistance
DDCs: Districts Development Committees
DOED: Department of Electricity Development
EDC: Energy Distribution Company
EU: European Union
FDI: Foreign Development Investment
FY: Fiscal Year
GDP: Gross Domestic Product
GHG: Greenhouse Gas
GoN: Government of Nepal
IBN: investment Board Nepal
ICS: Improved Cooking Stove
IEA: International Energy Agency
INGO: International Non Government Organization
IOC: Indian Oil Corporation
IPP: Independent Private Produce
IWM: Improved Water Mill
KW: Kilowatt
LPG: Liquefied Petroleum Gas
MICS: Metallic Improved Cooking Stoves
MLP: Multilevel Perspectives
MoE: Ministry of Energy
MOEST: Ministry of Environment, Science & Technology
MW: Megawatt
NEA: Nepal Electricity Authority
NGOs: Non Government organizations
NOC: Nepal Oil Corporation

NPC: National Planning Commission

NPOs: Non-Profit Organizations

PPA: Power Purchase Agreement

PV: photovoltaic

RA: Reverse Auctioning

R&D: Research and Development

RE: Renewable Energy

RETs: Renewable Energy Technologies

RES: Renewable Energy Source

RSC: Regional Service Center

SNM: Strategic Niche Management

TSI: Transformation Social Innovation

UNDP: United Nation Development Program

VCDs: Village Development Committees

WECS: Water and Energy Commission

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1. Introduction

1.1 Background

Energy transitions around the world have been triggered as multilayered, sociotechnical transformation projects that challenge established patterns of technology, business operations, and behavior. The description and analysis of energy transitions as "sociotechnical systems" include both technical and social elements and understanding how such socio-technical energy transition might be brought about is a major interdisciplinary research challenge in the societies. Researchers claim that "Large jumps in environmental efficiency may be possible with transitions to a new energy system (Weaver et al, 2000, cited in Verbong and Geels,2007). Thus, the energy transition can be an imperative tool to facilitate a new energy system. Since the socio-technical system defines the relation between technology and social aspects and the interaction between the existing system and novelties to bring innovation in the system

In the current situation of modernization, it is impossible to live without energy sources as all the exponential human activities rely on the provision, transportation, distribution and consumption of energy. Therefore, considerable technical and organizational means are directed towards finding sources of energy and providing the continuous allocation of useful energy in mechanical, chemical and nuclear form. In this energy supply chain, people mostly rely on carbon-based fossil energy which consumption has sped up dramatically over the centuries. According to the World Energy Outlook," The World consumers are not yet ready to say goodbye to the era of Oil"(IEA,2017). This statement clearly defines the situation of the world's energy sector which arouses a consensus among the majority of scientists that fuel-based energy causes climate change that endangered humankind and other habitats. In order to reduce global greenhouse gas emissions and avoid the most serious impact of the changing climate, the world is undergoing an energy transformation from a system based on fossil fuel to a system based on renewable energy. The capacity to use renewable energy sources (RES) is widely considered as the new emerging technology, which provides a solution to current energy demand and supply, CO2 emission, resource scarcity, dangerous technology, and hazardous waste. The current world energy outlook demonstrates the widespread implementation of RES and the speed of its penetration, even though the dominance of

carbon-based fuels still seems to be unbroken. In order to reduce the carbon-based energy system, society should metabolize energy towards a more sustainable and Green energy transition. Many studies have shown that energy transition is very complex and in order to gain an understanding of this transition it is not only sufficient to study the large scale of diffusion of new technologies but should also the behavior, values, and strategies of individual actors, as well as policies, regulations, and market, also shape energy transition system (Edwards, 2011; Foxon et al., 2010 cited in Li et al,2015).

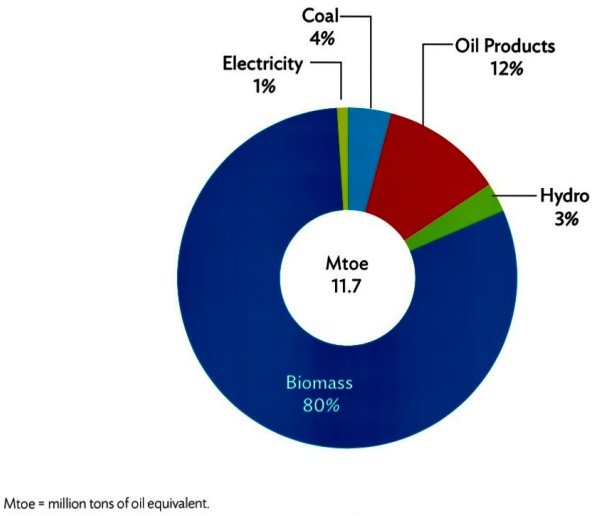
In the energy transition system, the socio-technical approach comprised three levels within the process of transition known as Multilevel Perspective(MLP). The external forces put pressure which is called landscape level, for instance, climate change, oil price, and these problems influence nations to bring the change in another level as Regime, at this level transitions are difficult since pre-existing practices or systems resist change, however, at niche level radical transformation is possible because of new actors are committed to innovation for economic development. Furthermore, innovation and advancement are possible if the external forces make pressure on a stable regime level to destabilize and then weakening regime initiate new opportunities. The socio-technical system has been used by many countries in energy transition and has achieved a successful outcome. The main purpose of this paper is to look deeper into how Nepal could transform its energy sector from traditional to sustainable through Green technologies by applying the socio-technical approach and tackle the fuel crisis and also find out various barriers and opportunities for deploying renewable technologies.

1.2 Energy Scenario of Nepal

Nepal is a landlocked country located in South Asia with an estimated population of 28.17 million. It is one of the least developed countries in the world (GDP—US$562) with 83% of the population living in rural areas(CBS,2012 cited in Gurung et al,2013,p1105). In the overall energy sector, The Ministry of Energy (MoE) develops and supports energy sector activities. Other administrative bodies under the MoE supporting the sector include the Water and Energy Commission Secretariat (WECS), the Department of Electricity Development (DoED), Nepal Electricity Authority (NEA) and fossil fuel supply is managed by Nepal Oil Corporation(NOC). In addition, the Alternative Energy Promotion Centre (AEPC) under the Ministry of Population and Environment is responsible for the promotion of renewable and alternative energy

technologies(ADB,2017). The Investment Board Nepal (IBN), established by an act of parliament in 2011, is the administrative body responsible for the implementation of Nepal's large infrastructure projects, including hydropower projects above 500 MW. IBN's legal mandate is to improve the country's investment by creating a framework for the selection and evaluation of projects, providing incentives and subsidies to encourage investments, negotiating concession agreements (Project Development Agreements), and carrying out investment promotion activities(Investment Board Nepal,2017).

Primary Energy Supply Mix,2014



Source: ADB,2017

Figure 1: Primary Energy Supply Mix,2014

Nepal's principal energy sources include biomass, hydroelectricity, petroleum products, and coal. The energy consumption pattern in Nepal is negligible, unreliable and dominated by traditional biomass energy sources which cover almost 80% of the energy sector(ADB,2017). Biomass which is in the form of firewood, agricultural waste, and animal dung has consistently dominated supply because of the lack of utilizing other alternative energy sources and the main reason behind this is the poor state of the economy, particularly in the rural areas(Gurung et al,2013,p1105). After fuelwood petroleum is the second-largest source of energy which accounts for 11% of the country's supply chain. For the past four decades, demand for petroleum products is solely met by imports especially from Indian Oil Corporation at Indian market rates under a long-term contract. Nepal imports roughly two-third of the oil for

transportation use and rest is used mostly for household lighting, cooking, and heating; and commercial and public services(IEA, Nepal,2016 cited in Gurung et al,2013,p1105). Nepal's reliance on imported fuels makes it highly vulnerable to international price fluctuations, and, as a landlocked nation, to foreign trade policy. For example, in 2015, a dispute between India and Nepal over the latter's new constitution led to a months-long blockade causing severe fuel shortages in the country. Nepal Oil Corporation, which is responsible for fuel distribution declared a "fuel emergency". Nepal accused the Government of India of deliberately cutting off Nepal's fuel supplies, a charge that India denied (Pokharel, 2015). This fuel blockade by India showcases the vulnerability of vital energy system and threaten human security and negatively impacts on the lives and livelihoods of the Nepalese community. The blockade was one of the incidents that made Nepal more attentive toward energy inadequacy and the Nepal Government to be self-sufficient and decentralized in the energy sector and find other renewable sources. This energy crisis situation showcase that the country should change it's the traditional paradigm from fossil-based systems to Green energy/ sustainable energy. In addition, beyond diversifying natural suppliers, Nepal's reliance on imported fuel provides an impetus for it to further develop its domestic energy options.

Nepal is rich in natural resources, which can be utilized for renewable energy production, especially in the form of electricity from hydro, solar and wind power. However, the country is still unable to utilize the full capacity of its natural resources for renewable energy due to political, technical and economic challenges. Currently, the nation's major focus lies in the hydropower sector which has the potential to generate 83000 megawatts and commercially exploitable hydropower generating the potential of about 42,000 MW(ADB,2017). However, by the end of the fiscal year (FY) 2016, existing hydropower stations had a total installed capacity of only 802.4 MW or less than 2% of the total commercially exploitable generation potential (ADB,2017). The Government of Nepal(GoN) intends to install 26 GW (42 GW considered to be financially viable) of hydropower capacity by 2035(Investment board Nepal,2017). At present Nepal is facing an energy crisis. Around 40 % of citizens have no access to electricity and the normal life of a citizen is being crippled with long hours of load-shedding up to 15 hours(ADB,2017).

Picture 1:Thousands of Nepalis line up for fuel in Kathmandu because of fuel shortage by as the "unofficial blockade" 2015

Source:https://diplopundit.net/2015/11/09/nepal-india-blockade-continues-usaids-programs-grinding-to-a-halt-and-the-ugly-in-the-horizon/

In Nepal, electricity generation, transmission, and distribution are managed by the state-owned, vertically-integrated utility, Nepal Electricity AuthorityNEA(ibid)). The state controls access to all markets and networks, and prices are set by the government. NEA suffers approximately 40 % of technical and commercial losses. The weak progress of hydropower development is caused by (i) inadequate planning and investment (ii) concerns about the ability of the Nepal Electricity Authority (NEA) to honor take-or-pay contract obligations; and (iii) delays in project development(ADB,2017). As a result, Nepal has been suffering from a severe shortage of power. Moreover, Nepal's hydropower sector is driven by its climate which is comprised of clearly delineated wet and dry seasons. Nepal's demand, however large it may be, cannot absorb all of its potentially great wet season production. Much of this power will have to be exported to the region. Conversely, during the dry season, Nepal will need to import power to cover its generation shortfalls.

While the situation may seem bleak in Hydropower, Nepal could focus on other renewable resources such as wind power, biogas, solar energy, geothermal energy and so on. Being environment-friendly, renewable energy also contributes to significant reductions in greenhouse gas (GHG) emissions, local/indoor air pollution, and minimizes the impact on the landscape,

and physical, geographical and natural environments. Thus, the decentralized renewable energy system is likely to improve the quality of life of the citizens in Nepal. However, in the context of Nepal, shifting the paradigm from traditional fossil fuels to sustainable energy is not an easy task. While transforming the energy different actors such as government, political situation, technology, institutions, geography, and climate plays a huge role in their development and overall energy activities. Therefore, the main purpose of this paper is to highlight the current status of energy production and consumption in the energy sectors in Nepal and elucidates the role of renewable energy in contributing to the energy needs in all over the country. The paper further reviews the major renewable energy resources available in Nepal and their current status and outlines the challenges and opportunities for promoting renewable energy technologies (RETs) in the country.

1.3 Renewable energy source in Nepal

Nepal is abundantly rich in renewable energy resources such as hydropower, solar energy, wind, biogas and other various forms of biomass energy. According to ADB statistics of 2013 12% of citizens had access to electricity through renewable energy sources. Among these renewable resources, 23 MW of electricity generation came from micro-hydro, 12MW from solar photovoltaic (PV) system and less than 20 kilowatts (KW) from wind energy(ADB,2017). The main objective of promoting renewable technologies in Nepal is to achieve energy independence and facilitate the energy requirement for the people. An affordable and reliable energy supply stimulates the country's economic growth. Thus, the present concern of the Nepalese energy sector is to increase the share of renewable energy in the national energy mix(Gurung et al,2013,p1106). Decentralized renewable energy supply systems, such as biogas, biomass, solar PV, micro-hydro, and improved cooking stoves, can provide feasible and sustainable supply options. Renewable energy technologies that have the future scope and can be used in Nepal include(ADB,2017):

(i) micro/mini hydro

(ii) biomass and biogas

(iii) solar PV and

(iv) Solar thermal energy (solar water heaters, solar dryers, solar cookers)

1.4 Barriers and Challenges of Deploying renewable energy in Nepal

The deployment of RETs which support sustainability still remains a big challenge for nations and stakeholders that are involved in the promotion of renewable energy resources in developing countries. In the context of Nepal, the development pattern of RETs is quite slow and subjected to various barriers such as lack of technical capability, lack of financing, rigid regulation, and policy, inadequate donors and so on. The main barriers to deploying renewable energy sources will be discussed below:

1.4.1 Policy barrier

The main factors that have prevented deploying Renewable energy in Nepal constitute a lack of national policies, corruption, bureaucratic and administrative hurdle, lack of standard and inadequate incentives(Seetharaman et al,2019,p7). Despite knowing the fact that energy is crucial for economic development, the whole Nepalese energy sector has not received much attention in the policy of the government. The government is trying to maximize the usage of renewable energy in rural areas. However, the government has not been successful because of the rigid legal framework that has to fulfill such as the Rural(Renewable)Energy Act, Central Rural Energy Fund Regulation and Rural Energy Central Coordination Commission Regulation (Gurung et al,2013,p1107).In order to full implementation any regulation on the energy sector, the government has to work with five ministries (Ministry of Energy, Water & Energy Commission, Water & Energy Commission Secretariat; Ministry of Commerce & Supplies; Ministry of Industries; Ministry of Environment, Science & Technology, Ministry of Forestry & Soil Conservation) and among them, there is no proper collaboration between them. Political instability in the country has greatly affected the development of RETs. Over the past three decades, Nepal has experienced three different political systems with more than a dozen different governments(KC et al,2011,p4115). These frequent changes in the political system and subsequent changes in the governments have adversely affected long-term planning and policy formulation for the development of RETs. One challenge in renewable energy is that it takes the long lead time to bring projects to completion due to political instability. Power companies take more than 10 years to complete just the approval stage and pass the design and complete in “five to twenty years” for even small projects(Sovacool et al,2011,p3472). In addition, the energy sector in Nepal is driven by centralized decision making which lacks transparency and caused

lengthy bureaucratic hurdles(ibid). Due to the lack of clarity, there is always the risk of misappropriation of the subsidies that are provided by the government in order to enhance the renewable energy sector. On the other hand, the government is directly or indirectly providing subsidy to import petroleum product that has favored the increased use of imported fuels in comparison to hydroelectricity (KC et al,2011,p4115)

1.4.2 Financial barrier

Large-scale renewable energy project requires massive capital investment. The government of Nepal does not have financial resources as this country is struggling with poverty. Nepal has one of the lowest per capita incomes in the world at less than US$350 per year, and about one-third of all homes live “below the national poverty line(Sovacool et al,2011,p3472). Therefore, the RETS sector of Nepal still highly dependent on donor-funded programs. The installation of RETs like the solar system, micro-hydro, and wind energy proved to be expensive in comparison to other traditional fuels and also appeared to be costly to distribute in the rural part of Nepal. To implement small hydropower projects require about 400 billion rupees, but the availability of funding in the local market is only about 8 to9 billion rupees which is less than 3% cost of a single project(ibid). Moreover, lack of purchasing power of rural area people and lack of RETs financial mechanism, the private sector is not motivated and reluctant towards investing in renewable energy(KC et al,2011,p4115).Many small hydropower projects facing financial problems since they have to sell electricity at the grid-based rate, which is lower than the cost of electricity generation and transmission. The situation clearly explains why since 1990 only 4 MW of small hydroelectric capacity has been built by the private sector (Sovacool et al,2011,p3472).In the survey of UNDP surveyed key lenders in the sector and noted that commercial banks and financial institutions are “generally not interested” in investing in energy(ibid). In addition, the inabilities to procure financing and foreign investment were also one of the obstacles in RETs. The lack of self-financing, poor financial operation of NEA, and low tariffs for electricity have created trouble luring FDI (foreign direct investment). The retail tariff imposed by NEA has not increased for a decade. Even though NEA proposed a 30% increase for anyone using 20 units still it is struggling and has a loss for the last eight-year (Sovacool et al,2011,p3472).Efforts to revise the tariff, however, “run into severe opposition from politicians and the public, who are against any increase in prices.”

1.4.3 Technical and environmental barrier

Numerous technological barriers exist to the widespread deployment of renewable energy, which include limited availability of infrastructure, inefficient knowledge of operations and maintenance, insufficient research and development initiatives, and technical complexities like energy storage and unavailability of standards(Seetharaman et al,2019,p7). In the situation of Nepal lack of technical capacity is one fundamental factor that impedes the deployment of RETs.In the rural part of Nepal, people are unaware of the benefits of RETS. Although they often have access to renewable energy they lack the understanding of these technologies(K.C et al,2011,p4115). Another technical barrier is hydrology and sedimentation of Nepal which include rugged and mountain alpine terrain endows with plentiful moving water but the SouthWest monsoon delivering is inconsistent(Sovacool et al,2011,p3472). The Country's 80% rain occurs from June to September and the remaining 20% falls as snow during the dry season. This mismatch between when water is available and when it is needed year-round to produce electricity creates a very complicated challenge (ibid). Nepal has different types of water sources, water from some fast-moving rivers that caused high floods which erode everything on the side, generate sedimentation that interrupts operating a hydroelectric facility. The second type of water source, spring water which is perfect for a hydroelectric station but sadly spring water is used first for drinking and irrigation, not electricity(ibid). Another technical barrier for deploying renewable energy is that poor infrastructure such as roads for project sites and transmission for the evacuation of generated power is grossly insufficient in remote parts(NPC,2013). Many sites that are in remote areas, at high altitudes and freezes over in the winter create an obstacle and made difficult in procuring technology and hiring experienced staff to install the remote system as to facilitate hydroelectricity well geographically and water conditions must be optimal(Sovacool et al,2011,p3472). Moreover, Nepal lacks the capacity to maintain its own micro-hydro technologies and it depends upon other countries such as Chinese engineers repairing them. Kailgandagi (144MW) could show a better picture of Nepalese low performance of human resources. Kali Gandaki is a hydroelectric power station, the largest in the country, the effect of silt on turbines and another infrastructure has degraded operational performance. Kali Gandaki hydropower does not have the ability to properly maintain the basin and must continue operating regardless of the incoming silt concentration. Moreover increasing the damage to the turbines could cause a risk of a serious accident. Inlet valves and turbines

also need to be repaired but the NEA lacks both the human and financial resources to do so without assistance from development donors(Sovacool et al,2011,p3472).

1.4.4 Socio-economic Barrier

The transition from traditional resources to renewable energy has encountered public resistance and opposition in Nepal. The main reason behind this is a lack of awareness among Nepalese citizens, aid dependency, social opposition from local communities and lack of financial capabilities and lack of government organizations that work for RETs. The first social challenge in deploying renewable energy in Nepal encompasses local opposition. In most villages of Nepal from upstream and downstream, the dispute between how to share water resources, in distribution the cost of installing a hydroelectric facility or using its electricity(Sovacool et al.,2011,p3474). If the local communities hear about a plan for a transmission line or hydroelectric plan they demand money. The social and strong political environment has influenced the local communities on a protest at almost everything(ibid). Another main reason for opposition is community relocation which is needed on the project which is above 10MW. The local communities are always against forced resettlement for hydroelectricity. They also have some kind of unrealistic expectation that building a dam is easy things and it will not take time. People think that building dams can solve all social problems and automatically eliminate poverty and improve their standard of living. In addition, they also believe that if hydroelectric facilities implemented it should serve them and the community for free, and poor families should not have to pay for electricity or at least pay a reduced rate well below production cost(ibid). Another social barrier deals with the expectation of international donors as Nepal is suffering from aid dependency. This dependence can be held hostage to what these donors want and often donor requirements contradict or unexpectedly change(Ibid). Another social challenge includes institutions set up in the Nepalese government for deploying RETS. At present AEPC is the single governmental agency that works for promoting RETS through subsidy. Due to the limited number of governmental agencies, there is a weak comprehensive integrated energy planning system in the villages and district levels(Gurung et al,2013,p1107).

1.5 Opportunities for Renewable Energy in Nepal

Renewable technology offers many opportunities as the RE technology is capable of making better use of locally available resources, such as solar power, biomass, wind, and hydropower. In Nepal, more than 63% of households do not have access to electricity and rely heavily on fossil fuels(Banerjee et al,2011,p1). This country has huge potential in renewable energy as it has huge natural resources. Deploying RETs in Nepal could have a significant impact on the rural area.RETs like Solar PV,mini-hydro power, wind energy could meet local energy demand of rural communities in a cheaper, cleaner and reliable ways. Moreover, researching and developing in such energy sources and decentralizing the energy supply could reduce the long-term dependence over India on imported petroleum fuel and likely to lower national debts which aid in improving the national economy(K.C et al,2011,p4114). In addition, Nepal with its enormous potential for RETs for electricity generation could become a major energy exporter to its neighbors' countries like China and India.

The energy transition from traditional fossil fuels to renewable technologies has made a tremendous impact on the social and economic growth in developing countries like Nepal. Green and reliable energy can contribute to income generation, increasing health and education quality, decreasing poverty level (Sen & Ganguly,2017,p1170). In Nepal, on average, rural women spend 5 hours per day collecting firewood (K.C et al,2011,p4114). They use wood for traditional cooking stoves in poorly ventilated places which cause serious health implications especially women and children hours in smoke-laden indoor environments(ibid). The new ICS(improved cooking stove) with biogas is enhancing the women working life and made a positive impact on their health. Apart from that rapid growth of major urban areas is due to the availability of electricity. Therefore many people migrated to urban areas with a better quality of life through energy intervention. If RE technologies are decentralized in rural areas and smaller towns of Nepal it can play an important role in rural development by generating local employment, health, education and an overall improvement in the quality of life. Overall renewable technologies based on decentralized production can play a significant role contribute towards poverty reduction and sustainable development of the nation. In addition, harnessing energy from renewable sources can dramatically improve electrification in rural areas and reduce the dependence on foreign fuel imports as well as traditional energy sources.

1.6 Limitation of the study

The limitations of the study are those restrictions and shortcomings of design or methodology that impacted the interpretation of the findings from research(Price and Murnan,2004,p66-67) Throughout the process of paper, we have to deal with some complications and limitations. The first complication we faced was a lack of interviews with the Nepalese electrical company and the local communities. If we were able to conduct interviews we would be able to gain a deep insight into the human phenomena such as experience, behavior and possible outcome of using the RETs in their social life. As we choose to work with the qualitative study, we face some problems in the data collection process. As our theoretical framework was based on a socio-technical approach which was mostly proceeded in European and Western society, but for a developing country like Nepal, it is just a newly emerging concept. Therefore, there was little research regarding this approach and we have to rely on a limited number of data that have influenced the data collection process. In addition, we are interpreting the gathered data under hermeneutics paradigm. This leaves us to open criticism that the process of translating philosophy into practice involves our own interpretation. While in seeking to make the interpretation of data clear to others, as a researcher we distill the philosophical principles which are necessarily become subjective and set these out in a way that is accessible and open to scrutiny. For this research, we have not emphasized much on defining and analyzing the landscape level as in our research case we put more focus on regime level and niche innovation as it plays a crucial role in the transition in the case of Nepal. Moreover, we are not looking for an in-depth study and insight into the health, economy, education, and political aspects. However, in the energy transition, these aspects play an important role, and also we limit our study due to limited time and limited pages. Therefore our study is focused on the existing energy sector, new technologies, and social innovation and the possibilities of the energy transition from traditional sources to renewable energy in Nepal.

2. Problem Area and Problem formulation

Nepal is abundant with natural resources with high renewable energy production and development capacities such as water resources to generate electricity from hydropower, as well as energy from solar and wind sources and efficient use of these resources could assuredly

fulfill the demand of energy in the country. Despite these facts, Nepal has been facing an unprecedented energy crisis because of the acute shortage of electricity and petroleum products and inadequate renewable resources production and its management. The government of Nepal(GoN) has declared and initiated many policies and reforms to fulfill the energy requirement of the country, however, because of numerous barriers and challenges, Nepal fails to meet the ever-increasing demand for electricity and some of these reasons are inadequate planning and delays in project implementation by authorities, lacks investment (ABD,2017) and also lack of technical know-how. Complete dependency and only channel for fuel imports, India, along with that less storage capacity in Nepal even worsen the circumstances in high demand.

The Government of Nepal has addressed the issues regarding energy production and consumption in the country through policies such as incentives and subsidies, investment awareness plans for private companies and for the local people to enhance renewable and clean energy and also has facilitated international investment agreements to achieve energy requirement in Nepal. Furthermore, energy production and development strategies are vital for the country to minimize the fuel risk and to become less dependent in India. Moreover, the government can resolve the energy production and consumption through technology development. Similarly, Innovation and technological advancement have become a necessary tool in any field for economic development in the modern era. As we discussed, many nations have had the achievement in the energy sector with the help of socio-technical transition and have resolved the energy problems and have produced notable renewable energy. Hence, the government of Nepal can also apply the socio-technical approach and technology innovation to overcome the energy crisis and can make efficient management, production, and consumption of available renewable resources in the country. In addition, various obstacles can also occur while making a new approach and change in society due to long term established practices and culture. The paper will study how renewable energy resources minimize the energy vulnerability and also the socio-technical approach can be used in Nepal to deal with the energy crisis and at the same time generate sufficient energy for the country through technological innovation and social interaction as well as study what could be the barriers and challenges that exist in the process. Therefore we find the topic interesting and would like to study the energy development possibilities to become less vulnerable to energy import and how the government of Nepal can have an impact on the solutions of the energy crisis. For our thesis problem formulation is:

How the government of Nepal is initiating renewable energy technologies to overcome the energy crisis in the country?

Sub questions;

(a) What kind of technological and social innovation are possible for energy production?

(b) What kind of barriers can occur at the technical and societal levels?

3. Structure of the thesis

As we have formulated our research question, now in the next chapter, we will discuss the methodology and in this chapter, we will be explaining the research design, research strategy, deduction approach, and qualitative data collection method including both primary and secondary data, which will help us to analyze the data and answer our problem formulation. After methodology, we will be reviewing various literature related to the socio-technical system applied in different developed and developing countries. This chapter will be followed by the theoretical framework. In the theoretical framework, we will be presenting our main theory, the socio-technical system and also we have presented two more theories institution theory and social innovation, these theories will be an important tool that will help in the analysis and answer the research question. Based on the methodology and literature review and theoretical framework, we will develop an analytical framework in the analysis chapter. Our main analysis will be based on the socio-technical system which involves the landscape level, the regime level, and the niche innovations. We have also analyzed institution theory and social innovation since these theories will support us to answer the problem formulation effectively. In the discussion chapter, we will discuss the socio-technical approach in the Nepalese context and will compare with other countries, the barrier, challenges that might affect the transition in the country and opportunities that will help to enhance the energy sector. In the last chapter, we will conclude our research and recommend accordingly and answer our research problem.

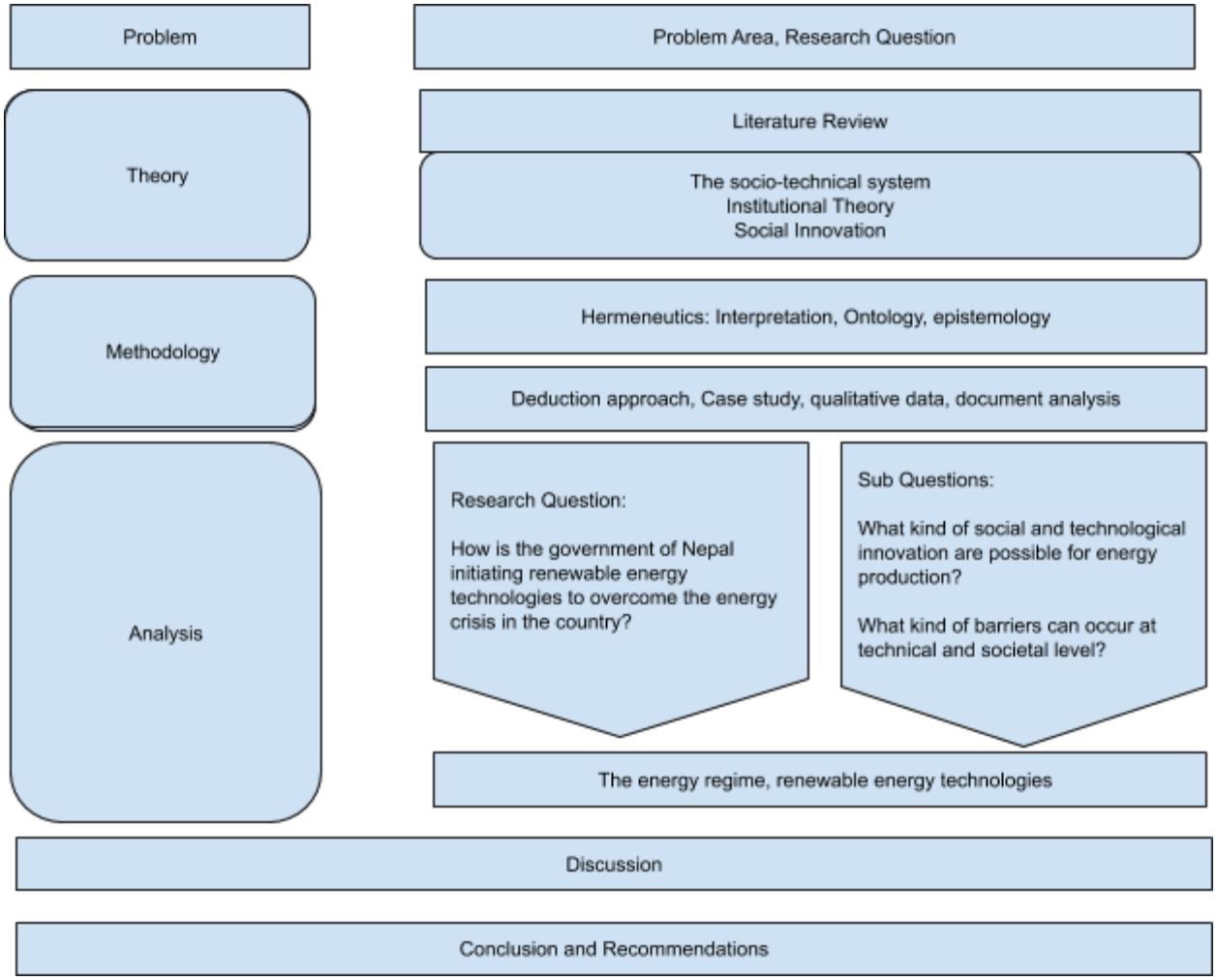


Figure 2:Overall conceptual framework of thesis

4. Methodology

In the methodology chapter, we will be discussing the Research Plan and design. In the research plan, we have elucidated the philosophy of science, research approach, research strategy, data collection method, and the research design of the thesis will be exploratory and descriptive study. In the methodology, we will explain hermeneutics as our research philosophy and the research approach will be the deductive approach for answering our research question. Similarly, in the research strategy, we plan to collect data as a case study method for our thesis since we are focusing on the energy transition in the Nepal case. In the data collection methods, we will be using qualitative data as primary and secondary data both to analyze and answer the

problem formulation. We have collected primary data from various sources such as annual reports and official websites of energy authorities Nepal Electricity Authority(NEA) and Alternative Energy Promotional Center(AEPC) and official videos. Likewise, secondary data were collected from books and journals related to energy, energy transition, innovation, etc.

Data collection techniques and methods are important to answer the research problem, data collection and data analysis lie in the center of research onion. “You are not unusual if you begin thinking about your research by considering whether you should, for example, administer a questionnaire or conduct interviews, However, thoughts on this question belongs in the centre of the research ‘onion’, by which means we have chosen to depict the issues underlying the choice of data collection techniques and analysis procedures” Saunders et al.,2009,p.106).

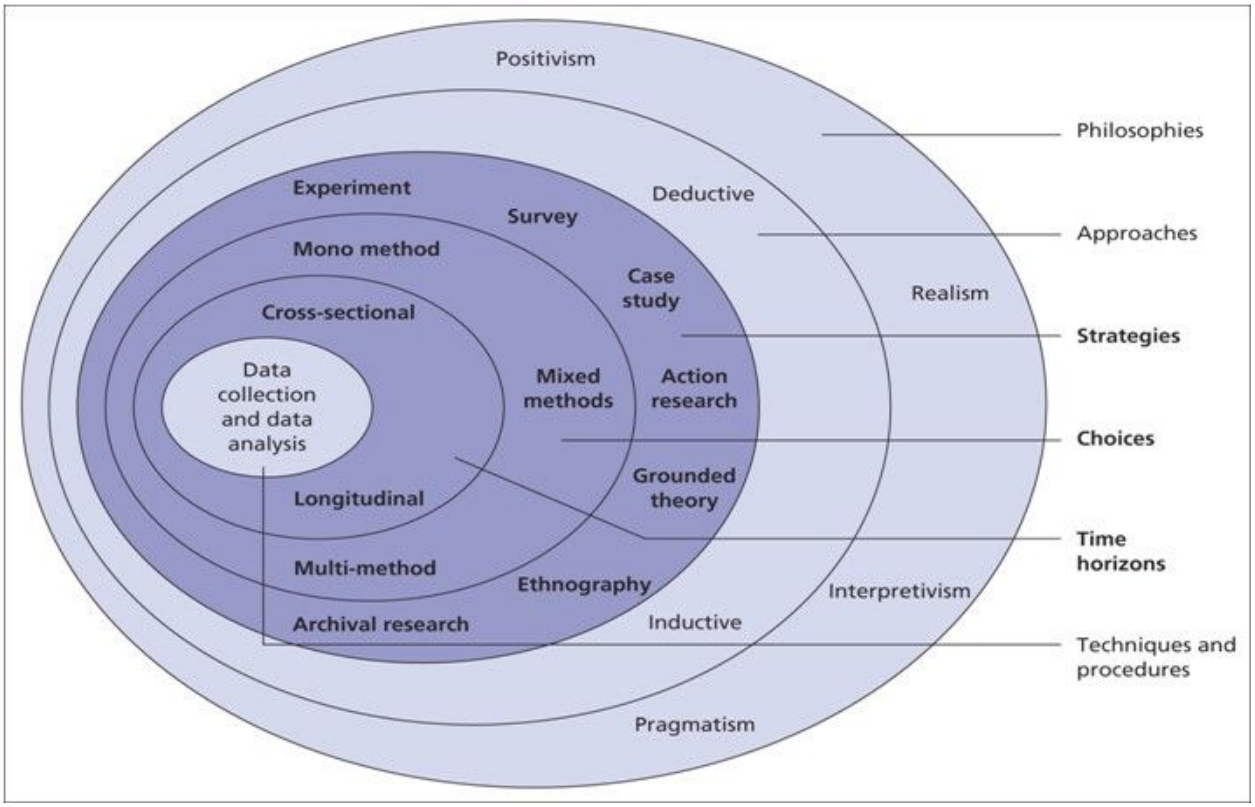


Figure 3: The research ‘onion’

Source: Mark Saunders, Philip Lewis, and Adrian Thornhill, p.138,2009.

4.1 Philosophy of Science

4.1.1 Hermeneutics

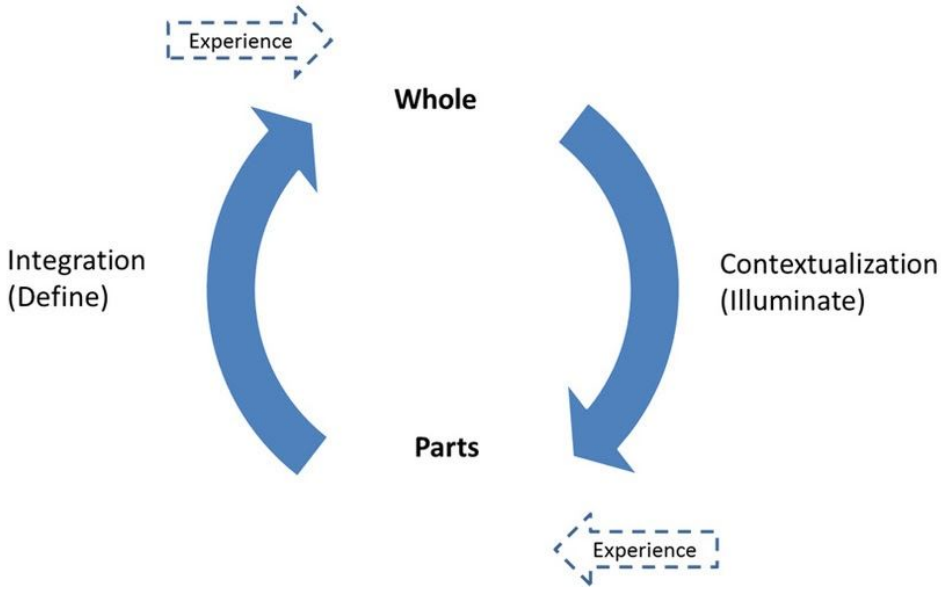
As there are many different concepts and research paradigms that have been developed by philosophers, it is important to select the right one in order to associate it with the kind of research we are doing. Therefore, to help make sense of how our research was conducted and the scientific thinking behind the work, a view regarding hermeneutic is essential. Hermeneutics is the theory and practice of interpretation of experience that emphasizes how we cope in the world and come to understand objects and subjects(Barrett et al,2011,p182). While its origins focus on the study of biblical texts and later ancient and classical cultures, the philosophy of hermeneutics offers a way of understanding the process of interpretation(ibid). The understanding or interpretation of hermeneutics itself is not without contention. Hermeneutics has been interpreted in multiple ways over time, from the theory of the critical explanation of historical religious texts to systems of interpretation.

The name Hermeneutics is derived from Hermes the Greek messenger of God whose work is to interpret knowledge and understanding between the gods and mortals(ibid).In the 17th century, hermeneutics became associated with the interpretation of a text, particularly in the context of bible studies. Since then, a number of philosophers (Dilther,1998; Heidegger,1962; Gadamer,1975; Richour,1976; Shleimacher,1977) have argued, elaborated and developed a variety of hermeneutic philosophy and subsequent methodologies.Schleiermacher(1977) has been acknowledged as the founder of modern hermeneutics, moving beyond the illumination of the biblical text to the illumination of human understanding. Subsequently, Dilthey broadened the field of interest of hermeneutics beyond the individual to include cultural systems and organizations(Patterson& Higgs,2005,p 346). Hermeneutics in the tradition of Dilthey and Schleiermacher is considered as providing methodological principles for objective interpretation, whereas in the tradition of Heidegger and Gadamer hermeneutics represented ontology of relativity(ibid).

Heidegger and Gadamer uphold the view that the interpretation made by a “historian” or researcher is influenced by their pre-understandings. Heidegger (1962) emphasized the ontological perspective of hermeneutics are concerned with an inquiry of the theory of being,

and the idea of understanding of being (Dasein) that happens prior to reflection. According to Heidegger interpretation is not just meaning while it is grounded in a whole set of background practices, a kind of pre-understanding that makes knowing possible(Barrett et al,2011,p187). Heidegger stressed on a three-fold structure of being that are: relating to the past, articulating the situation in the present, and pressing forward to the new possibilities of the future (Titchen, 2000 cited in Barrett et al,2011,p187). One implication of Heidegger's insight is that self is always already participating in a context that guides the projection of meaning; knowing is never an achievement of isolated subjects. One is already embedded within a tradition of Beings (Barrett et al,2011,p188). He extends the notion of the hermeneutic circle - not just the relation between subject and text but also the relationship between self-understanding and understanding of the world(ibid). Heidegger associated hermeneutics with phenomenology and emphasized self-consciousness and the primary function of words in creating understanding, or the ontology of language(D.Guzys et al,2015,p9).

Figure 4: Use of the hermeneutic circle in this project. (adapted from Bontekoe, 1996)



source: Bontekoe, 1996, p.4

Gadamer further developed this ontological concept through his efforts in establishing hermeneutics as an ontology of the event of understanding. Gadamer's focus was not on processes to facilitate understanding, but rather on how understanding is shaped through the experience of exposure to text or art(ibid). Gadamer considered understanding as a historical,

dialectical, and linguistic experience. He rejected ideas of the objective subjective binary, as all human understanding is subjective (Gadamer, 1989). Although a person may attempt to be objective, their understanding is shaped by the history of their personal knowledge and experience. Yet, new knowledge cannot emerge if the old is not challenged; therefore, an attitude of openness and interrogative communication is required. A final element of Gadamerian philosophy is that there is no final or absolute truth when understanding is open and anticipatory. For Gadamer, understanding is less a cognitive achievement than a practical one. To understand something is to be able to apply a skill, such as a cook engaged in cooking or an engineer designing a tool(Barrett et al,2011,p189). Gadamer adds another dimension to what it means to "understand". According to him understand is related to the agreement and understanding a text is akin to entering a dialogue between conversation partners seeking to achieve some kind of common ground(ibid). For Gadamer, understanding, application, interpretation, and translation are terms that are almost interchangeable.

Gadamer (1975, 1981) believed that the hermeneutic circle of interpretation is never closed but is ongoing, with the movement of understanding from the whole to the part, and back to the whole. He emphasized the need to acknowledge their biases and prejudices for a researcher as part of the interpretive process of hermeneutics. Biases bring forth meaning by anticipation, expectation, and projection. Further, Gadamer introduced the concept of understanding research findings through a fusion of horizons. The historical horizon of the past and the present horizon of the current interpreter bridge the gap between the familiar and the unfamiliar. The goal in hermeneutic research is to look deeper into the horizons of past, present, and future understanding through a hermeneutic circle, relating, "the thing itself to the dialogue between the text and the reader" (Aylesworth, 1991, p. 74). " A horizon is not a rigid boundary but something which moves with one and invites one to advance further".(Gadamer,1960,p245). The statement of Gadamer defines the reader of the text extends or projects his/her horizon toward a text, object or and event(Barrett et al,2011,p.190). Ricoeur also explored this theory as a metaphor of a "relation between the literal meaning and the figurative meaning which is like an abridged version within a single sentence" (Ricoeur, 1976, p. 46 cited in Paterson & Higgs,2005,p346). Gadamer embraced the concept of metaphors as a "linguistic process of concept formation… a reversible, oscillating, circular movement".(Weinsheimer, 1985, p. 238)

In hermeneutic the subject of the research is humankind and their understanding and prejudice which is influenced by their culture, tradition, and knowledge. This leads to a connection to our research problem which investigates the influence of technology in a societal context that has changed the regular human practice, pattern, values, and behavior. The main reason behind choosing this concept to our case because Interpretive research starts out with the assumption that access to reality (given or socially constructed) is only through social constructions such as consciousness, language and shared meanings. Hermeneutic studies generally attempt to understand phenomena through the meanings that people assign to them. For our research, the constructivist paradigm is suitable in which two perspective needs to be differentiated which are ontological elements and the epistemological elements. The ontological perspective of our research in the hermeneutic paradigm is that reality can be multiple as it is constructed in a different situation and altered by the knower. This ontological perspective dictates the epistemology stance that reality needs to be interpreted to discover the underlying meaning of the research. The epistemology is grounded on the belief that knowledge-making is possible through subjective experience and insight

4.2 Research Approach

4.2.1 Deductive Approach

The thesis will use the deduction approach and in the deductive approach, the aim is to deduce theory before the researcher collects and gather data to answer the research question. “Deductive research moves from general ideas/theories to specific situations; that is, a particular idea/theory is deduced from a general aspect e.g, broad theories”(Godwill, 2015,p.11). This approach provides a researcher comparatively consistent and efficient way of testing theories in a particular situation. Robson (2002 Cited in Saunders et al, 2009, pp 124-125) explains the five orderly stages of deductive research study for its progress, firstly hypothesis deduced out of theory and then study how variables and concepts can be operationalized or measured by framing the hypothesis, the next stage is to test the hypothesis and then again investigating the results or findings whether the theory is appropriate or any changes are needed. The last stage is to alter the theory according to the findings if necessary and try to revise again the whole cycle from the 1st step to last.

Deduction research approach consists of various imperative features. The First one is, it tries to describe the relationship between different variables and hence we formulate a hypothesis and then we use another feature to test the hypothesis i.e collect qualitative data or quantitative data. It leads to another feature of deductive, control to hypothesis testing and these control provides a systematic and structured methodology that enables replication, which is an important matter to reliability certainty. The further important feature is where idea /concept is operationalized for facts measurements and the next feature is reductionism which indicates that problems as a whole give a better understanding when they are reduced to easy and simple sections possible. The last feature of the deduction approach is generalization and therefore move from a general idea to a specific/particular situation (Saunders et al, 2009,p.125).

4.3 Research Strategy

4.3.1 Case Study

“The case study method is a technique by which individual factor whether it can be an institution or just an episode in the life of an individual or a group is analyzed in its relationship to any other in the group”(Godwill, 2015,p.22). Case study research includes the description and interpretation of circumstances, incidents, events of a specific “case” that are arising in the current time. The Author further explains “Its distinguishing characteristic is that each respondent is taken as a unit and the unitary nature of the individual case is the focus of analysis” ibid. The case study helps to understand complicated problems or object and it can advance the knowledge and extend the experience to already known facts or knowledge through earlier research. Similarly, this research strategy stress on detail contextual analysis of finite or limited circumstances or events and their relationship at the same time.

Moreover, Author Godwill argues, “Case study research method can also be defined as an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used”(2015,p.23). Case study research strategy also has a substantial potential to originate and produce answers to ‘why’, ‘ what’ and ‘how’ questions and is distinguished by the use of various sources of data. “The case study strategy will be of particular

interest to you if you wish to gain a rich understanding of the context of the research and the processes being enacted(Morries and Wood 1991, cited in Saunders et al, 2009).

4.4 Data Collection method

4.4.1 Qualitative Research Method

Qualitative data are widely used data collection methods in business and management research studies whose main focus is non-numeric or word/text data for analysis procedures. This method uses non-numeric data hence refer to not only data other than words but also videos and pictures to analyze and answer the research problem(Saunders et al.,2009,p.151). “Many of the volumes on qualitative research emphasized the research process and demonstrated that qualitative research cannot be reduced to particular techniques nor to set stages, but rather that a dynamic process is involved which links together problems, theories and methods”(Bryman and Burgess,2002,p. 2,) Thus, the qualitative method rarely includes the use of simple or easy procedures, rather a researcher has to move back and forth between various series and sequences in the process of investigating and defines the links and relationship between problems, theories, and methods.

The qualitative data helps to understand the meaning through words and proper analysis of these types of data and the analysis carried out through conceptualization. “While ‘number depends on meaning’(Dey 1993:28), It is not always the case that meaning is dependent on number. Dey(1993:28) points out that ‘ the more ambiguous and elastic our concepts, the less possible it is to quantify our data in a meaningful way’. Qualitative data are associated with such concepts and are characterised by their richness and fullness based on your opportunity to explore a subject in as real a manner as is possible”(Dey,1993:28: Robin 2002, cited in Saunders et al,p. 482,2009). Similarly, author Kumar (2011) argues that “the main focus in qualitative research is to understand, explain, explore, discover and clarify situations, feelings, perceptions, attitudes, values, beliefs, and experiences of a group of people. Therefore, qualitative research is generally flexible and are less structured and sequential in the operationalization of these types of data collection method.

4.4.1.1 Primary and Secondary Data

Mainly two methods are used to collect information concerning the person, any problem, situation or phenomena and on some occasions, we gather data as required or sometimes data are available and only are reused as needed. We gathered and collected both primary and secondary data from several sources to analyze and answer our problem formulation."Information gathered using the first approach is said to be collected from primary sources, whereas the sources used in the second approach are called secondary sources"(Kumar,2011). We collected primary data from the sources below:

- Data from the official Homepage of the energy providers
- Companies Annual Reports

The primary data such as official websites and annual reports have been collected and used that helped us to answer our research question. Primary data are new data collection in the research to answer the research formulation. Authors Hox and Boeije elaborates "Primary data are data that are collected for the specific research problem at hand, using procedures that fit the best"(2005,p.593). Primary data contributes to new experience and knowledge in existing knowledge every time the research is conducted.

Secondary Data

- Books, Articles and Journals related to the energy system, energy transition, innovation, renewable energy technology, etc.
- The government published energy statistics, official texts, and figures.
- Nepalese E-Newspaper
- International organization published reports

Secondary data provides useful and handy sources to answer the research problem and these types of data consist of raw and published data such as books, articles, journals and so on. The materials gathered by others, for instance, universities, individual scholars and researchers, and research institutions, etc, and then made available for reuse, such data are known as secondary data(Hox and Boeije,2005,p.593). As our research problem is mainly related to the government role in the energy system in Nepal, hence our secondary data are government official publications, surveys, journals that are published within the government representative or

department and these data constitute the highest quality data sources that are available for answering our research problem. Since they gathered by skilled and trained teams to collect that information and then publish those data. Data collected by the Government are more efficient and effective secondary data(Smith,2008,p.6). The author further argues, “Given the highest level of funding and expertise that goes into the development of government surveys, they can often represent the highest quality data that are available. Their scope is generally large and their population can be highly representative, which aids robust inferences.”(Sales et al, 2006, cited in Smith,2008,p.6).

4.5 Research Design

Research design is a purpose and plan of research to acquire an answer to research problems and it provides the complete procedure or program of the investigation. It shapes what a researcher will do starting from making a hypothesis until analyzing the data(Kerlinger 1986;279, cited in Kumar, 2011). “A research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure”(ibid). Hence, research design influences us to decide and communicate our decision on what kind of design a researcher proposes to use and data collection, their selection from our respondents and correspondingly analyze and communicate the results. For our thesis, we will use the descriptive research design and then we will explore the knowledge through exploratory research design.

The purpose of descriptive research is,“ to portray an accurate profile of persons, events or situations’’(Robson 2002:59, cited in Saunders et al,2009,p.140). Authors further argue, “This may be an extension of, or a forerunner to, a piece of exploratory research or, more often, a piece of exploratory research” (ibid). Thus, it is important to be clear about the phenomena that what type of data the researcher needs to collect before data are gathered. However, the researcher should also be aware that the work done should not be very descriptive, it should also extend and draws conclusions from the collected data that has been described. Author Kumar (2011) explicates that descriptive research purpose provides useful insights and guidance to the formation of hypothesis and helps to identify the elements or features of the subject. Descriptive research obliges to describe a case and then provide new insights and understanding of the problems.

An exploratory research study is a useful way of finding new insights into the research. It helps to develop a better understanding and gives proper direction to the chosen problem. “An exploratory study is a valuable means of finding out ‘ what is happening; to seek new insights; to ask questions and to assess phenomena in a new light” (Robson 2002:59, cited in Saunders et al,2009,p.139). The exploratory study purpose is more flexible and changeable as needed. Authors explain,“ If you are conducting exploratory research you must be willing to change your direction as a result of new data that appear and new insights that occur to you”(Saunders et al,2009). In addition, Adams and Schvaneveldt(1991) support the above point by claiming that “the flexibility inherent in exploratory research does not mean absence of direction to the enquiry. What it does mean is that the focus is initially broad and becomes progressively narrower as the research progresses”(Cited in Saunders et al,2009,p.140). Moreover, exploratory research is highly used research generally used in case studies and reviews of prior studies, it usually addresses the phenomena where there are uncertainties and avoidance regarding the subject or when the problems are not properly understood and only a minimum amount of research has been done in the events. (Godwill, 2015,pp 16-17). However, the absence of specific approach and its broad nature, it seldom gives a specific solution or answers to the particular research problem, yet the answers might not be exact in this method, the researcher needs to find the important issues, relationship between variables and should be able to draw conclusions in the research (ibid).

4.6 Reliability and Validity

Since reliability and validity are important aspects that measure the quality of the research, thereby we should carefully look into these concepts to maintain the quality, value, and appropriateness of our thesis. Closely looking into these two specific influences on research design i.e reliability and validity, help to minimize the possibility of obtaining the wrong answer in research.

Reliability refers to the extent to which your data collection techniques or analysis procedures will yield consistent findings” (Saunders et al,p.156). If the research shows consistency in research result then it is reliable and accurate. Author Kumar describes “ The concept of

reliability in relation to a research instrument has a similar meaning: if a research tool is consistent and stable, hence predictable and accurate, it is said to be reliable. The greater the degree of consistency and stability in an instrument, the greater its reliability"(2011). Hence the test is reliable to the degree when measures produce the same result in repetition or produce the same consistent findings on other occasions also. It examines the degree of accuracy or error-free measures produced by research tools, so the lesser error in tools and techniques, the stronger the reliability of the research. Sometimes various elements affect the reliability of the research resulting in impossible to achieve 100 percent accuracy because some elements are out of control of the researcher and these factors can be an environment, inappropriate timing, changing attitudes and opinion of respondents, etc.

"Validity is concerned with whether the findings are really about what they appear to be about"(Saunders et al,2009,p.157). The validity concept looks into the measures that they were designed for which means if the research tools are finding out what they were meant to be or not. "In terms of measurement procedures, therefore, validity is the ability of an instrument to measure what it is designed to measure: Validity is defined as the degree to which the researcher has measured what he has set out to measure(Smith 1991:106, cited in Kumar, 2011). Kerlinger explains the concept of validity as: are we finding out what we actually think we are finding out (ibid).

In addition, several debates occur on the importance of reliability and validity in qualitative research because most answers are explored from various measures and methods and at the same time are flexible and ever developing nature which are not fixed and unstructured. Author Guba and Lincoln have developed four important tools that ensure reliability and validity in qualitative research. According to them, trustworthiness and authenticity set the quality in qualitative research. The reliability and validity of the qualitative research are shaped by four tools and they are credibility, transferability, dependability, and conformability(Kumar, 2011). Credibility incorporates that the findings in qualitative research are credible and believable, Transferability helps to explain the process so that the others follow and repeat. Likewise, dependability indicates reliability through the detailed recording of the procedure for other researchers to replicate. The final one is confirmability, it indicates the degree by which the findings are verified by others and follows a process in a similar manner to achieve the findings and findings are compared accordingly (ibid). Therefore, it is possible to develop the reliability

and validity of the results in qualitative research with the help of the model developed by Guba and Lincoln through identical procedures and data collection methods.

The qualitative data were gathered aiming to be the quality data since the data were collected from the government official sources and these data are determined to meet the needs of the governmental purpose, these data assures the quality since they are well defined and properly documented. “They are usually clearly defined, well documented and of high quality” (Saunders et al,2009,p.260). Hence, our topic is mainly based on the government's role in the energy sector and the progress they have achieved, so our data are mostly governmental published data and other recognized international organizations such as UNDP, ADB. When we contemplate achieving high reliability, we involved more than one researcher while analyzing the data and we examine the references, reports and other sources so that the research in the future will replicate and the outcome likely will be the same. Similarly, validity defines the relationship between variables and a researcher should be able to identify these relationships, hence we have analyzed the relationship between the energy system and innovation so that the validity compared to be high.

4.7 Empirical Section: The case of Nepal

In this empirical section, our main focus is on the socio-technical approach in the energy sector of Nepal. Nepalese people are mainly depending on traditional sources of energy such as oil and gas, and biomass to fulfill their energy needs. The country is highly dependent on imported fuel that is imported from the Indian Oil Corporation(IOC) and consistently experiences fuel crisis. Therefore, we explored the traditional energy system, changes the government implied in the sector and the development of new technologies in Nepal.

As the demand is increasing and the Government of Nepal looking for more alternative resources to achieve its energy demand. To understand the interaction between various actors molding the transition in the energy sector, our method is assisted by qualitative data acquired through document analysis such as data from the government official reports, official journals, and articles, official videos, homepage, reviews from other researchers and scholarly literature, etc. By exercising these document analyses, we gathered and identified important energy reforms, policies and innovative transformations that have been done in the sector and explored

these responses and tried to link with our theoretical expectations. In addition, with the help of this, we were able to give an outline of Nepal's energy system, investigated the need for socio-technical transition and recognized the important role of actors in the process. Moreover, we explored niche innovations as renewable energy technologies(RETs) and their important role and possibilities in producing sufficient energy for the country.

Nepal is largely dependent on fossil fuel energy and its energy sector is dominated primarily by the government. The energy consumption rate by the public mainly fuelwood accounts for 70.47% and the second-largest consumption is petroleum products accounts for 12.53% whereas Electricity is only 3.39% and renewable consumption accounts for only 2.49%(WECS, 2017). Furthermore, the residential sector consumes the highest percentage (90%) of total energy in Nepal unlike industrial sector consumption is mostly highest in developed nations(Gurung et al, 2013). Likely, however, Nepal has an abundance of natural resources to commence the energy transition that would minimize fossil fuel dependency and help to overcome the energy crisis. At the same time, Nepal is the second-largest country in water resources and its main electricity is produced from hydropower resources. Unfortunately, it lacks install capacity which is very low only 800 MW due to technical and financial limitations. "Water resources in Nepal can be harnessed to produce about 43000 MW. However, the theoretical potential is estimated to be around 83,000 MW" (WECS, 2017). Similarly, merely 75% of the population is covered who has electricity access and within that 58% is coupled to a national grid and 9% in the rural sector has an off-grid system.

Although the government of Nepal has initiated renewable energy resources(through its Official alternative energy centre AEPC) in urban and rural areas to fulfill the energy demand, installations are mostly high in rural areas to make proper electricity access in the country. The government is running the operation within two programs, one is solely by the government itself and another one is in partnership with other external development partners. Correspondingly, several reforms and policies have been formed by the government in energy production and distribution, yet many political issues and technical, financial barriers restrict the energy production and RETs installation in the country. Overall, there are various possibilities and need for socio-technical transition in the energy sector especially because Nepal is rich in natural resources and possesses a good climate to produce alternative renewable energy resources from hydropower, solar, wind sources, etc. in spite of these possibilities innovative

transformation could not penetrate the energy regime or drive the necessary transition in the sector. The table below shows the renewable energy production capacity of Nepal:

Technologies	Estimated Potential	Basis
Mini/Micro Hydro	>100 MW	Possible in 55 Districts of Nepal
Domestic Biogas	1.1 million plants	At existing livestock population
Solar Energy	2100MW	4.5 KWh/m sq/day radiation if 2% area is taken as being acceptable
Improved Cooking Stoves	>2.5 million	Assuming 75% eligible of the total households by the 2011 census
Improved Water Mill	25000-30000 MW	-
Wind	3000 MW	Assuming 10% of the area with more than 300W/m sq
Biofuel	100000 tons	Assuming 10% area with more than 300W/m sq

Table 1:The renewable energy potential of Nepal
Source:(Poudyal et al, 2017)

Basically, the energy regime in Nepal is centered and rigid system governed and operated by the government of Nepal. Although the government has brought many reforms and changes including the partnership with other private energy providers, foreign investors, however, they get very low share and also rules and regulations are also very rigid and mostly in favor of the government itself. Such issues discourage other actors to involve in production and distribution and also invest in the sector. The regime actors in the energy system in Nepal are the Ministry of Energy, Department of Electricity Development, Department of Environment, Nepal Electricity Authority, Nepal Oil Corporation, Alternative Energy, etc. Since the energy sector is regulated by the government, it highly influences the socio-political regime as well. Corrupt practices also

make fossil fuel dependent and restriction on new technology development. The landscape is influencing and putting pressure for the transition globally for many environmental protection issues and Nepal is also aware of the fact and has initiated niche innovations by developing various renewable energy technologies(RETs) long ago but due to several reasons, these technologies are not implemented properly and Nepalese government still unable to fulfill the energy demand of the country.

Renewable energy technology programs are successfully implemented to a certain degree, yet the government is unable to produce the energy to fulfill the energy demand. In the table below, the list of renewable technology programs implemented in the energy sector till 2017/18.

Program	Unit	Achievements till FY 2017/18
Mud Improved Cooking Stoves (ICS)	Nos.	1,423,242
Solar Home System	Nos.	850,643
Domestic Biogas	Nos.	416,060
Micro/Mini Hydro	KW	30,706
Institutional Solar PV System	Nos.	1,752
Metallic ICS	Nos.	55,892
Improved Water Mill (IWM)	Nos.	10,857
Urban Solar Home System	Nos.	21,144
Solar Drinking Water and Irrigation Pump	Nos.	486
Solar/Wind Mini-grid System	KW	413
Large Biogas Plant	Nos.	189

Table 3: Cumulative achievement in technology promotion

Source: AEPC annual report 2017/18.

5. LITERATURE REVIEW

In this chapter, we will review the cases of the socio-technical approach applied in various countries and also its success and failure expectations in the process. And we will also discuss the socio-technical approach and its need for the energy transition in the case of Nepal.

There are many problems associated with the energy sector from decades such as climate change or other environmental issues such as carbon emission, different types of pollution, fuel crisis, fuel dependency and reliance and so on. The energy sector is one of the critical affairs for many nations whether it is concerned with environmental issues or its shortage. “The energy sector faces serious problems, e.g, oil dependency, reliability, and environmental problems”(Geels,2007,p.1025). However, these issues related to energy sectors can be solved through energy transitions and could be possible to make it more efficient. According to different authors, many developed countries have achieved success by adopting the energy transition system to manage or tackle energy issues and have solved them through various alternatives such as renewable energy options, low carbon emission technologies, etc(Geels,2007).

5.1 The Socio-technical System

The socio-technical system comprises both society and technology together and their interaction in transforming or innovating in the existing system. “Socio-technical systems- the interlinked mix of technologies, infrastructures, organizations, markets, regulations, and user practices that together deliver societal functions such as personal mobility” (Geels et al, 2017). The socio-technical system covers not only the technology but also all the aspects of societies that are linked together to bring transformations in society.

Authors have stated that transitions as moderate and continuous procedure of transformation, where structural features of society changes and it involves changes in various connected aspects that support each other, however, these aspects function in their respective areas, these are; the economy, institutions, cultural aspects, normas and belief systems and so on. Moreover, these changes are not easily accepted and can be restricted in society(Auvinen and Tuominen,2014,p.354). The Transformation in the socio-technical system is described by three different levels and these are the landscape, the regime, and the niches. “The socio-technical

landscape relates to material and immaterial elements at the macro level: material infrastructure, political culture and coalitions, social values, worldviews and paradigms, the macro economy, demography, and the natural environment. The second level, that of a regime(Meso level), relates to dominant practices, rules, and shared assumptions. At the meso level are interests, rules, beliefs and organizations that guide private action and public policy. For the most part, these are geared towards optimizing rather than transforming systems. The niche level(micro level) relates to individual actors and technologies and local practices. At this level, variations and deviations from the status quo can occur, such as new techniques, alternative technologies, and social practices"(Auvinen and Tuominen,2014,p.354).

As stated in the Multilevel perspective (Geels, 2004; 2011), the important landscape changes impact on sustainability and balance the regime in the socio-technical system. The energy transition is a huge change that not only has a positive impact on the energy system but also it transforms the system of other sectors such as healthcare, agricultural regime, and overall economic affairs(cited in Loorbach, 2016,p 70). Given below are some examples of the countries who adopted the socio-technical transition to bring sustainability and efficiency in the energy system;

5.1.1 Electricity transition in Netherland

In Netherland also various developmental actions have been planned and implemented regarding renewable energy sources since the 1970s. Especially for electricity production, policymakers and also other groups or actors are also associated with renewable activities. Public authorities and government influenced this change as well. The researchers' elaborate socio-technical transition in Netherland case study, as they explain, the electricity regime was very rigid and was managed by utilities and Arnhem corporations, and they had full dominance on the system. Later on, the government initiated natural gas production and public-private schemes were introduced. Furthermore, they brought a heating system in buildings and private homes. This whole process continuously generated change in the existing regime Verbong and Geels,2007,p.1027).

After the fuel crisis in 1973, the landscape level put pressure globally, then the Netherland government became more aware and responded to various environmental issues and tried to focus on the electricity regime and the country began to focus on energy policy. The

government prepared the document as Energy White Paper for new energy policy."With the White Paper, two new criteria were added: diversification of energy resources to reduce dependency, and energy efficiency to reduce environmental impacts"(ibid). Although, regime actors were upset about transformation and government intervention. The government brought many changes from natural gas to renewable resources to minimize oil dependency and environment issues. According to researchers Netherland adopted the socio-technical approach and based on MLP, introduced numerous changes and development since 1970 and to date to the future at different three levels. The country through energy policy initiated development in renewable resources such as biomass and electricity. At the niche level, the government established a new actor for production, distribution and supply-side which was the energy distribution company(EDC). It has also attempted to produced Solar power, however, due to geographical location, solar power was not that efficient. Similarly, due to less cost-effective, wind energy also could not generate power as the nation had expected. Overall, Netherland has given more attention to organic biomass to generate electricity and energy-saving policy. The climate change, fuel crisis, and other continuously growing environmental issues forced the regime level, where at this level new laws, rules and regulations regarding energy policy in Netherland influenced the government for transformation and new innovators or actors were developed at the niche level.

5.1.2 The energy transition in Brazil

The Brazilian population has been dependent on fuelwood for cooking in households which leads to indoor air pollution resulted in adverse effects public health as well as deforestation and inefficient energy consumption practice in the country. So that the government started the energy transition as fuelwood replacement for Liquefied petroleum Gas(LPG) for cooking in households. The government regulated and declared many policies and emphasized on using oil than fuelwood and offered subsidies on LPG. The action resulted in an increasing rate of using modern gas instead of traditional fuelwood. Moreover, the government succeeded in changing the inefficient cooking practice to more cleaner option(Coelho et al,2018).

However, due to various reasons such as poverty, the public could not afford LPG for cooking and resulted in people come back to old practices. Also other issues like security problems(explosion), cultural problems, etc. Although the government provided protections like price subsidies to poor families still price and infrastructure were some of the reasons that

resisted the action. The energy transition from fuelwood to LPG was designed in processes but highly influenced by affordability. “On the one hand, the energy transition history of fuelwood replacement for LPG in Brazil shows that policies and planning were able to address key challenges. On the other hand, recurrent removal of subsidies without other forms of financial support for the poor has impacted the affordability of Brazilian households when it comes to fuel choice for cooking”(Coelho et al,2018,p.50). Therefore, the government should focus on its challenges and make financial support and other subsidies policies that could completely bring the transition from fuelwood to LPG for cooking in households in Brazil.

Similarly, various other nations also have implemented the energy transition such as a transition in low carbon in Germany electricity system, renewable energy transition in Nigeria and so on and equally face challenges but have achieved their goals accordingly. Emerging environmental and social problems, for example, oil prices and dependency, climate change, health issues globally and these problems need a sustainable transition in energy, agro-food system, transport, and overall economic growth and environment protection. Even though existing patterns resist change due to respective affairs, however innovators or supporters encourage and protect the action of transformation for development. Therefore, according to studies, the socio-technical approach can be an imperative tool for any country facing problems mostly in the energy sector through system transition.

5.1.3 The energy transition In the context of Nepal

Fossil fuels and traditional fuelwood dependency of Nepalese people to meet their daily energy requirements and together with experiencing an energy crisis, all these factors require a serious transition in the energy sector in the country. “Statistics reveal that households in the country have more affinity towards solid fuels as a primary fuel for cooking followed by the use of Liquified Petroleum Gas (LPG)”(AEPC report, 2017/18). The socio-technical approach based on the multilevel perspective(MLP) defines the interaction between three levels drive the transition in the system and these three levels are the landscape level, the regime level, and niche level. The smooth interaction among these levels helps to bring the transformation in the country(Geels,2017,p.1242). According to MLP, the exogenous landscape level puts pressure on the regime and then regime which is usually rigid due to various existing patterns. However, it helps to bring change through the third level which is niche innovation, at this level new novelty emerges and they support innovation.

In Nepal, the regime system is complex and rigid because the highest portion of the energy sector is regulated by the Government of Nepal and other sector's share is significantly low such as private sectors and foreign sectors. The government has gone through big reforms in 1985 to bring changes in the electricity sector, but the plan has remained unsuccessful because of the structural issues of the sector. As the demand for electricity was continuously growing and the electricity regime became more attentive to proper energy management. "A sequence of major electricity reforms initiatives was mooted after the creation of Nepal Electricity Authority(NEA)"(Nepal and Janasb,2011). After the establishment of the NEA, many legal provisions, plans, and policies were formulated for the development of hydropower electricity. The public-private partnership was initiated for the development of hydropower through licenses and encouraged the installation of small hydropower projects in rural areas. Foreign Investment and Technology transfer Act of 1992 was begun to promote investment and technology. Many changes were started in the energy sector for its efficient production and distribution, however, political instability, corruption regarding licensing, rigid rules and regulations, the sector could not achieve the required electricity in the country.

For the stimulation of the socio-technical transition, the three main processes should support each other by creating flexibility in the existing regime, strong influences from external pressure and promotion and development of niche innovations(Geels et al, 2017). Likewise, the government of Nepal is being unable to accomplish the necessary energy demand only from mega hydropower projects and also importing fuel is not enough that results in, the country undergo a continuous energy crisis. The country adopted renewable innovation policies in between 1985-1990), however, the constitution of Nepal (2015), the government declared and ensured the policies to proper management of renewable energy production to achieve the energy demand and fulfill the needs of the people through renewable energy. The government has promoted innovative technology in renewable energy sources through its alternative centre AEPC for producing and distributing energy and these niche innovations are known as Renewable Energy Technologies (RETs). The transition from traditional fuels to renewable energy sources could be an imperative step for Nepal to fulfill its energy demand. The regime actors have encouraged the momentum of these technologies such as Improved cooking stoves, biogas plants, solar photovoltaic systems, wind turbines, Improved water Mills, etc. The

state is supporting these innovations by providing subsidies, attracting private and foreign investment and technology, involving local communities in production and sales.

Nepal has been through various reforms in the energy sector for effective and efficient production and distribution of the energy, along with that the government has attempted to embrace new technologies in the sector to enhance the proper balance between demand and supply of energy, due to the many challenges, barriers the country still could not produce sufficient energy for its people. About 69%of its population depends on traditional energy, knowledge and information gap between state actors which means the federal/formal structure, poor grid connections, and technical know-how, these are some of the challenges hindering the implementation of new technologies in the country. Therefore, to overcome issues related to the effective operation and management of the energy sector, the socio-technical approach could be a vital tool for Nepal. The right balance and interaction between the regime system and novelties could enhance and drive niche innovations in the sector. The country has been through many reforms and also adopted transformation still due to rigid and complicated structure and monopolist nature, the policies and implementation are not giving the result as expectations. Hence, the socio-technical method can provide the right direction to the existing energy system in Nepal, which is from traditional energy to green transition and would help to produce the energy from available renewable sources that the country rich in and manage it effectively.

6. Theoretical Framework

In this chapter, we will present the theories which will be applied to the analysis of the data. Firstly, we will explain the socio-technical system and energy transition and then we will elaborate on institutional theory and social innovation. These theories will help us to understand and analyze the energy transition and relationship between three levels in the multilevel perspective, institutional paradigm, and social innovation.

6.1The Socio-Technical System and Energy Transition

The energy transition from fossil energy sources to renewable sources is not an easy process in socio-technical systems. It consists of transformative change in various elements such as economic relations, politics, rules and regulations, landscape alteration and also, transform

technologies. But in the end, as in any complex socio-technical transition, “System changes only happen when enough people do enough things differently enough”(Watson,p.488,2012, cited in Labanca,2018). The transition is possible at multilevel and the multilevel perspective is an important technique to analyze transition and its management. The multilevel perspective(MLP) has three levels: the landscape level, the regime level, and the niche level. These levels provide a better understanding of the socio-technical transition.

6.1.1 MultiLevel Perspective Theory (MLP)

The socio-technical scenario consists of Multilevel socio-technical theory in transition that is also called a multilevel perspective(MLP), it has an important role to explain the transition in any innovation.“This theory not only explains transitions in terms of technological innovation and user practices but also examines the societal factors in transition pathways”(Osunmuyiwa et al, 2017). This theory consists of three levels and they are; the landscape level, the regime level, and the niche level. These three levels are interlinked and influence each other in transition processes. The landscape-level consists of different external influences such as climate change, oil price, etc and these factors give pressure that affects the overall processes. The second one is the regime level which constitutes the existing phenomena and includes rules and regulations, existing patterns, the organizations that are involved in managing the energy system. Finally, the third one, the niche level, these are the innovators who support or nurture new technologies. Hence, the Multilevel perspective states that transitions take time and are everlasting transformations that happen at these mentioned three levels(ibid).

The multi-level perspective is used to do long term analysis of the electricity system and these three levels in MLP develop a sort of hierarchy. Innovators always try to support innovation but get restricted by many factors and take time to develop because already existing rules, laws, beliefs, and other established forces restrict new developments. “Historical studies have shown that transitions only come about when developments at all three levels link up and reinforce each other”(Geel,2005; Van Driel and Schot, 2005, cited in Verbong & Geels,2007,p.1026).

6.1.1.1 The Regime Level

The regime level in socio-technical approach manifests the meso level that is composed of interconnected elements(Geels,2005); “ (a) network of actors and social groups; in the electricity regime important actors are utilities, the Ministry of Economic Affairs, large industrial users, and

households;(b) formal, normative and cognitive rules that guide the activities of actors;(c) material and technical elements; in the case of electricity, these include resources, grid, generation plants, etc."(Geels,2007,p.1026)

6.1.1.2 The Niche Level

This level focuses on development and innovation and manifests micro-level in Multilevel Perspective(MLP). This level includes new markets or novelties where resources are given by public subsidies."Niches act as 'incubation rooms', shielding new technologies from mainstream market selection"(Geels, 2007,p.1026). The Author further adds, "Such protection is needed because new technologies initially have low price/performance ratio"(ibid). Shielding is mainly provided by a small group or network of actors who want to invest in a new idea and new technologies for development. The niche level consists of learning processes, new social network establishment and follows and guides innovation relating process.

6.1.1.3 The Landscape Level

The Landscape-level forms the macro level at Multilevel Perspective in Sociotechnical system. Verbong & Geels(2007) explains, "The macro level is the socio-technical landscape, which forms an exogenous environment that usually changes slowly and influences niches and regime dynamics". The landscape put pressure on the niche level and existing regime and bring new innovations and opportunities in society. "Niche- innovations may breakthrough more widely if external landscape developments create pressures on the regime that lead cracks, tensions and windows of opportunity"(Geels,2010,p.495). Hence, this level concerned with global issues and it waggles to both the other two levels the regime and the niche to open up with new technologies and possibilities.

Many Multilevel perspective literatures are mainly defining the interactions and relationship between regimes and niches(Kemp et al, 1998; Geels 2004,2011; Schot et al,1994; Schot and Geels 2008, cited in Loorbach et al,2016,p.71). "The regime, on the one hand, is characterized by stability and lock-in mechanisms. The niches, on the other hand, harbor innovations(novelties that deviate radically from the regime(ibid). Geels(2004) states that regimes hold three kinds of rules: regulative, normative and cognitive. The key concept of MLP is that interaction within processes of different levels. The niche level develops an internal driving force and then the landscape level puts pressure on the regime level where the regime

opens opportunities and possibilities for niche innovations. Niche-innovations are imperative but they have to disseminate broadly if they get connected at the landscape and the regime continuing process(Grin et al,p.88,2010, cited in Loorbach et al,2016,p.71).

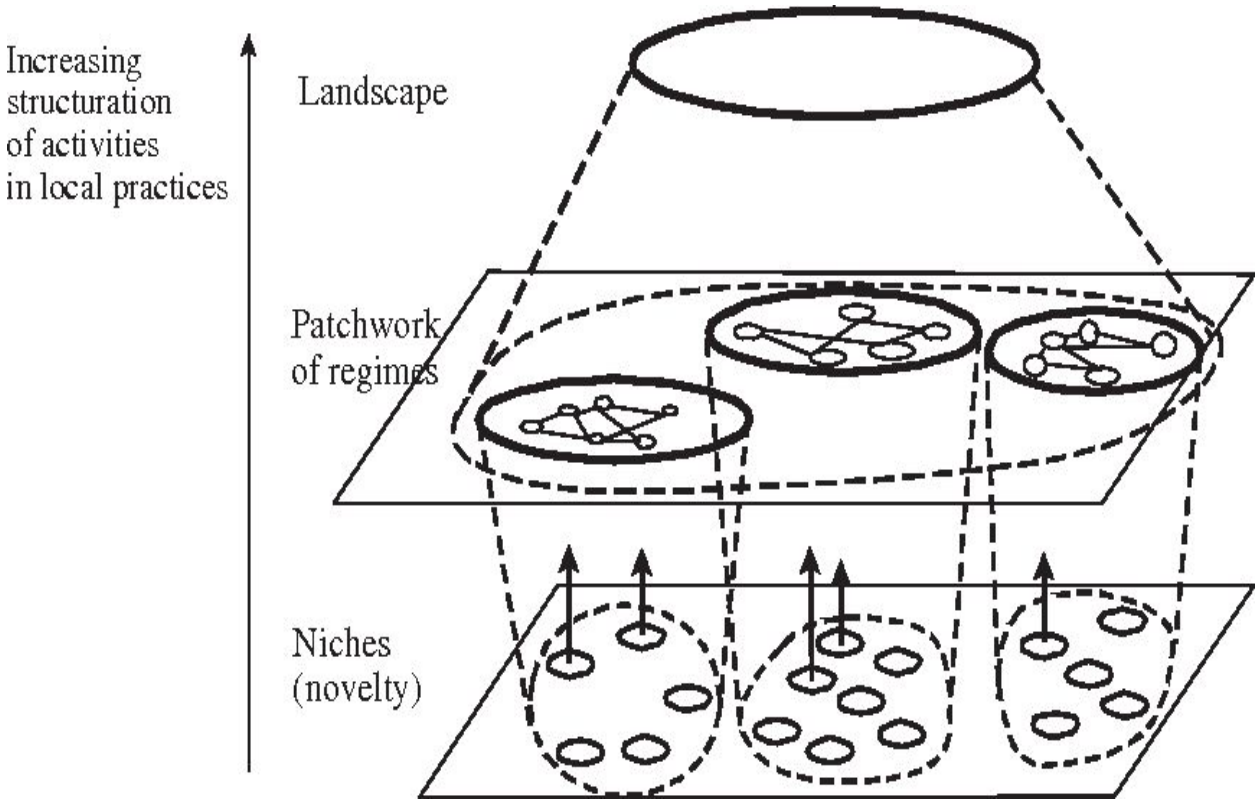
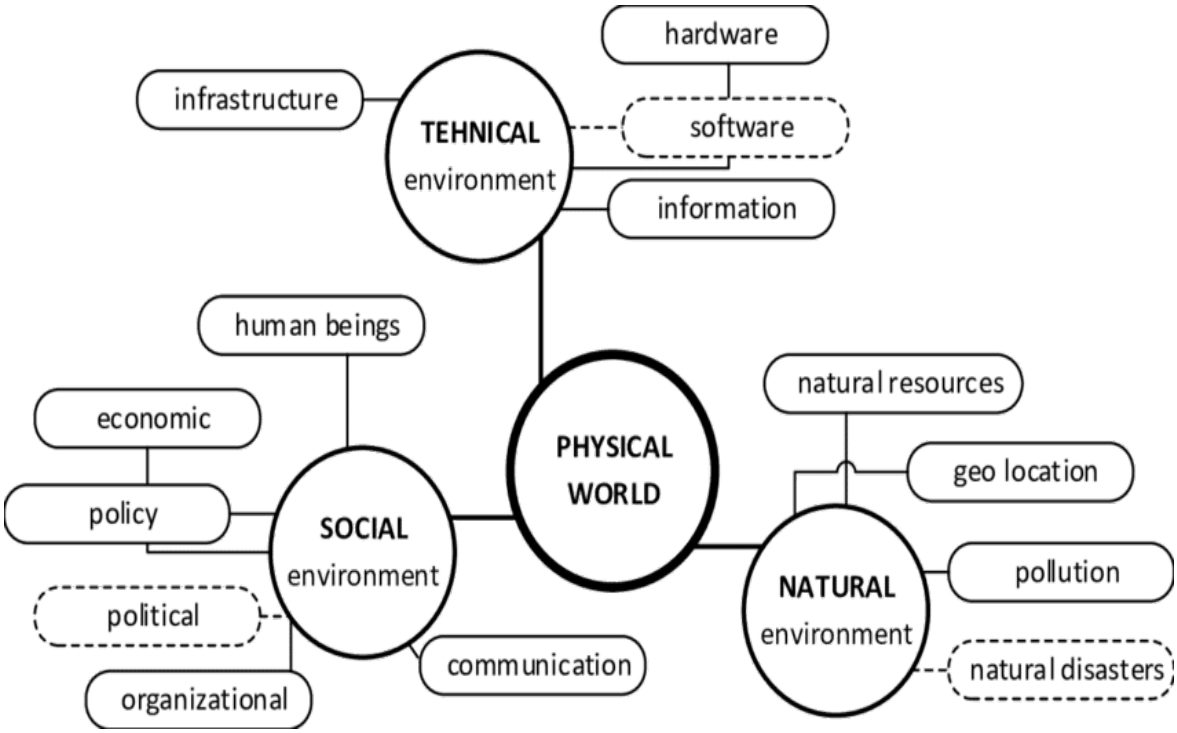


Figure 5: Multiple levels as a nested hierarchy (Geels, 2002, p. 1261)

To stimulate this whole process, researchers state regarding transition management such as "Loorbach(2007,2010) argues that a combination of multilevel activities is necessary, some strategic and long term, some tactical and mid-range, and some operational, putting a stake in the ground. And perhaps most importantly, reflective activities are needed to connect ongoing development (strategic, tactical, operational) to the continuously changing state of the system and the regime."(Loorbach et al,2016,p.72). The governance method and strategic niche management(SNM) in transition management stress the significance of novelties in niches but they do not advise the governments to make niches in a top-down manner. Both encourage

internal driving, driving from within and such force can direct various parts of the process through connecting and adding a new actor, consisting learning process that leads towards a set of goals. And with this, processes of practice promote the transition prospects of niche novelties(ibid).

In the energy system, several authors have described the different tools to study the socio-technical transition, however, it has been recognized that only eco-innovation has considered the main component for sustainable development and overall growth and at the same time they are recognizing that they are focusing merely on the natural environment and technical innovation and social factors are not considered thoughtfully. These social elements are people, policies, economy and other such interactions in the system(Timma et al,2017,) p.419). Yet some authors have studied these sectors by putting them together as the social, technical and natural environments. All three sectors are presented below in the figure:



Source: Timma et al,2017, p.419

Figure 6: Hierarchy of socio-technical systems

6.2 Innovation and Institutional Theory

The energy transition from the traditional method to renewable energy generation is a huge phenomenon and it includes transformative changes in the institutions that regulate and guide the society to get effective and efficient energy production and consumption. The institutional theory defines social structure such as rules, standards, beliefs, values, and culture of the society and these elements shape behavior and pattern of the people and their communities that they belong to(Andrew,2015). The Author further argues, “Institutions include symbols, frames, and values that determine a set of practices that are specific to a particular culture and may have no relationship to economic efficiency”(Ibid).

Scott explains that institutions are formed by three elements and these are normative, regulative and cultural-cognitive, all these aspects provide the right balance and meaning to social life(Cited in Carvalho et al, 2017). These elements are present in any well established institution that defines social behavior. Furthermore,“ These three institutional pillars are defined, as facets that strengthen and reinforce structures”(Scott, 2001, cited in Carvalho et al, 2017). Rules and regulations are established and monitored by the regulative element which sets rewards or punishments accordingly to control future behavior. Similarly, the normative rules give pressure on obligatory divisions to social life and this system consists of norms and values. The third component, the cultural cognitive influences the existence and the interaction among actors in society and these are symbols such as signs, words, gestures. These three components are important tools in the change process in any society.

The Three Institutional Pillars.

	Pillars		
	Regulative	Normative	Cognitive
Bases for conformity	Obedience	social obligation	Accepted as true
Mechanisms	Coercive	Normative	Mimetic
Logic I	instrumentalism	Conformity	Orthodoxy
Indicators	Rules, laws and sanctions	Certification Credibility	Predominance Diffusion
Bases for legitimacy	Legally sanctioned	Governed morally	Culturally sustained Understandable Recognizable

Table 4: From Institutions and Organizations by Scott (2001), p.52.(Cited in Carvalho et al,p.253,2017).

According to Schumpeter,1985, “Scientific and technological development demands constant change, being the principal agent of Technological Innovation. However, innovation doesn’t occur in isolation but depends on various factors within the organizational contexts and this development corresponds to the phenomena of revolutionary changes in the productive life of a society”(Cited in Carvalho et al, 2017). So the technological innovation is continuously changing process which depends on various events and brings change and efficiency in the society.

Geels,2010 describes that “Institutional theory explains innovation based on cognitive institutions that seek legitimacy so that they’ll be accepted. This legitimacy constitutes a mechanism that links organizational behavior with belief systems and public opinion in which change occurs as a response to institutional pressure”(Cited in Carvalho,2017). In addition, Geels argues that innovation represents such features that it is fully supported by institutional theory since it attributes governing objectives and showcase determination and it rewards and

benefits not only an individual but also to the collective, for that reason it requires legitimacy and institutional pressure. Hence it involves social interaction, technology, and public outlook(2010).

Different studies have closely analyzed the function of institutions with innovation and researchers have questioned the existence of innovations and technologies without institution. “According to the definition of institutions as patterns of habitual behavior, we can see that these patterns are necessary for the existence of any productive activity”(Carvalho et al, 2017,p.255). Therefore, institutional theory confers institutional analysis and legitimacy in the theory of innovation. The authors add that, “institutional theory is more broadly similar to the Socio-Technical Approach to Innovation due to its emphasis on how the cognition, actions, and interactions of agents is shaped by institutions including norms, routines, common habits, established practices, rules, and laws”(ibid).

Previously, researchers tried to apply institution theory in the energy sector to describe its changing features and outcomes for improving this sector in communist European nations and the Former Soviet Union. Moreover, in other various energy sides such as electricity, in many oil companies and also in technological innovation, the institutional theory has been used in the past. “Studies that go beyond the conventional analyses of governance and regulation to emphasize the need to change values, beliefs, and behaviors in society relating to energy security”(Andrews,2015,p.10). As claimed by many authors, in socio-technical regimes, the institution is explained as an important tool to analysis regime transition. The institution is described by some authors just as formal and informal routines, standards, norms, and beliefs, however, these aspects are organized, applied, analyzed in socio-technical regimes, particularly in Scott’s approach(ibid).In the socio-technical regime, the extensive institutional approach delivers meaningful insights and at the same time, it elaborates how basic characteristics of the economic and political systems and culture can develop and influences energy transition.

6.3 Social Innovation

There are multiple definitions exists of innovation, basically defined as,“ new ideas that work”(Mulgan et al,2007,p8). Innovation that is developed and designed specially to address the social or environmental issue is not the new one. However, it is only recently that research, deliberate practice and the formulation of bespoke policy agendas focus especially on “social

innovation" have begun to emerge. Unlike another form of innovation, social innovation can be understood as " innovative activities and services that are motivated by the goal of meeting a social need and are predominantly developed and diffused in the organization whose primary purposes are social"(Ibid). In most cases, technological and commercial innovations tend to have profit motives whereas social innovation is concerned with the wellbeing of communities and society. In addition, social innovation frequently tends to deal with collective, societal challenges. Basically, social innovation is the process and the outcomes that develop a novel approach to address society's social problems or needs. In addition to addressing energy problems, social innovations typically also contribute to attaining social goals, like community empowerment, alleviating (energy) poverty, and increasing the general well being of the community.

The concept of social innovation is considered hard to grasp as social innovation can have multiple meanings. The difficulty in defining social innovation is because it includes both innovations, including technical innovation which involves social processes and every social change which could be described as innovative in one way or another(Bergman et s, p3). Another Scholar Cajaiba-Santana(2014,p 45) distinguishes two ways of analyzing innovation in which each based on a separate theory. "On the one hand, Social innovation is based on an individualistic perspective that seeks to find an innovative solution to social problems in one community that are not met by the local system". On the other hand, social innovation is based on the structural perspective implies that structure and context(Social Entrepreneurship and Public policy) are the main factors explaining innovation. According to Cajaiba-Santana social innovation processes analyses society's structural adjustment abilities to accommodate new ideas and practice. Social innovation manifested in changes of attitudes, behavior, or perceptions, resulting in new social practices.Social innovation is said to induce social change and inventing new alternatives for social interaction and practices. Social innovation induces the reconfiguration of social practice, institution, and networks in such a way that new modes of practice emerge(Hewiit et al,2018)]. Therefore, social innovation has a high potentiality in addressing complex issues and in relation to the innovative ability and sustainability of society.

In recent years, social innovation has received increasing scholarly attention especially on the concepts of energy, energy system and energy transition. The transition to a renewable-energy economy, as part of the energy transition, is a collective, complex and long-term process

comprising multiple actors for social changes (or innovations) which involves far-reaching societal, technological, organizational, political, economic and socio-cultural changes. In energy transition, a fundamental task is to identify those actors who may affect the transition to renewable energy. Based on the literature, five actors can be distinguished: government, the public, markets, the 'third' sector, and the traditional energy industry. The 'third' sector this sector includes various stakeholders having specific interests mainly those of non-governmental (NGOs) and other non-profit organizations (NPOs). Hoppe and De Vries(2018,p13) conceptualize social innovation in the energy transition as "Innovations that are social in their means and contribute to the low carbon energy transition, civic empowerment and social goals pertaining to the general well-being of communities". Hewitt et al (2019,p2) even argue that social innovation emphasizes the role of civil society in creating new ways of responding to crises and opportunities. While Others view social innovation from a participative governance lens, focussing on co-creation and co-production with citizens and stakeholders. Voorburg et al. (2015,p. 3) define social innovation as, "the creation of long-lasting outcomes that aim to address societal needs by fundamentally changing the relationships, positions, and rules between the involved stakeholders, through an open process of participation, exchange and collaboration with relevant stakeholders, including end-users, thereby crossing organizational boundaries and jurisdictions". The central focus of social innovation is evaluating pathways of changing relationships between state, market economy and civil society(Moulaert et al, 2005). Examining these relations can reveal multiple, sometimes contradictory processes that enable and constrain the potential for social innovation to develop through community mobilizations. In summary, social innovation can be understood as the reconfiguring of social practices in response to societal challenges, with the aim of improving societal wellbeing through the engagement of civil society actors.

Social innovation is increasingly viewed as a way of addressing societal challenges which is able to contribute to viable alternatives and pathways that trigger transformative change at both individual and collective social levels(Hazeltine et al,p5). Hazeltine et al conceived a theory of transformative social innovation(TSI), which illustrates how TSI processes lead to transformative change, and how social innovation networks, (bottom-up) initiatives and citizens are empowered(ibid). In contrast to other analytical approaches of social innovation, TSI does not solely focus on the 'niche' level but also acknowledges the 'regime' level, which contains elements like institutions, social structures, and incumbent actors that strive to maintain the

status quo and often form barriers to social innovation and the transformative change it seeks to incur (Ibid).

Taking insights of the above-mentioned concepts into account, a concise definition of social innovation is coined by the Bureau of European Policy Advisors(BEPA,2010,p7)], which states that "social innovations are innovations that are social in their ends and means". Social innovation is a novel approach that mobilizes people's creativity to develop solutions and make better use of scarce resources. (BEPA 2010: 7). Interest in social innovation is also reinforced by recognition that addressing major societal challenges requires broad changes in societal discourses, issue framings, values, behaviors, habits and participation rates alongside structural, infrastructural, institutional and organizational changes. In conclusion, in relation to the energy transition, social innovation can be defined as such innovative activities that are social in their means and contribute to the Green transition and sustainable environment, civic empowerment and general wellbeing of communities. In addition, social innovation is also associated with the issues like social behavioral change, new social configuration, new organizational forms, new forms of governance, novel policies and regulation to empower social groups to engage in low carbon energy activities.

7. Analysis

To answer the research question of our thesis, the analysis will be based on the socio-technical system framework, thus it will focus on the three-levels of Multilevel perspectives which are the landscape level, the regime level, and niche innovations. This approach will help us to analyze the existing regime, niche innovation trajectory, and the landscape pressure in the energy sector of Nepal and at the same time, the interaction between these levels to generate green energy. Additionally, different barriers at technical and societal levels will be analyzed to answer the problem question more effectively. We gathered data from various quality sources and identified these three levels in the context of Nepal, so we will be analyzing the data on how these levels interact and support each other and could bring transformation in the energy system and how the government can produce the sufficient energy for the country through the energy transition. In addition, we will analyze the institutional structure of the energy system in Nepal and the impact of new innovations in the country through social innovation prospects. Hence, first of all, we will analyze the electricity regime and changes and niche innovations, secondly, institutional paradigm and social innovation in the energy sector and finally we will deduce our answer to the research question.

Analyzing the gathered data, we have prepared the table below which outlines the three levels of multilevel perspective the landscape level, the regime level, and the niche level that comprises the socio-technical framework in the context of Nepal.

The Landscape Level	Regime Level regulators	Niche-Innovation(RETs)	Other actors
❑ Climate Change ❑ Fuel price ❑ Fuel Dependency ❑ Fuel Crisis	❑ Ministry of Energy(MoE) ❑ Department of Electricity Development(DoED) ❑ Department of Environment(DoEnv) ❑ Nepal Electricity Authority(NEA) ❑ Nepal Oil Corporation(NOC) ❑ Water and Energy Commission(WEC) ❑ Alternative Energy (AEPC)	❑ Improved Cooking Stoves ❑ Improved Water Mill(IWM) ❑ Solar Photovoltaic System ❑ Wind turbines ❑ Biogas Plants ❑ Mini/micro hydro plants	Private energy providers Foreign investors

Table 2: The Multilevel Perspective in the context of Nepal

7.1 Socio-technical system and the energy transition

Raising energy demands, increasing energy prices and climate change has grown the necessity to produce and use renewable energy technologies. The renewable energy is promoted since it is sustainable and environment-friendly and on top of that, it facilitates the future of independent energy. Therefore, energy transition from traditional energy to renewable energy has grown the interest of many nations to fulfill the energy demand and to support the clean environment. The energy transition could be an important technique for a major bounce to independent energy and environment efficiency(Weather et al, 2000, cited in Geels,2007). In the case of Nepal, the major problem is a complete dependency on energy imports which results in an energy crisis or shortages and financial burden. Thus, the government of Nepal can use the energy transition as a tool to move from traditional energy to renewable energy, a central place to overcome its energy problems and scarcities.

Although the Nepal Government has made several plans and policies in the energy system and also encourages production and consumption of renewable energy, however, the proper

implementation, and efficiency of these policies and resources are very low to achieve the energy demand of the nation. The GoN has made many efforts to produce and implement renewable energy sources since the 1980s to ensure the electrify, not only the cities but also rural Nepa(AEPC,2018/19). Therefore, this paper will analyze how Nepal is initiating new technologies in the energy sector to ensure sufficient energy for the country and likewise, will analyze the changes in well established electricity regimes. The paper will focus on the electricity sector in Nepal and its regulatory policies and plans and niche innovations such as hydropower, solar, wind, biogas, and biomass technologies.

7.1.1 The Electricity regime and changes

As our interest in the energy transition, we apply the multilevel perspective, which defines the interactions between existing regimes and niche innovations. The energy sector is run and influenced by public authorities in Nepal, produced and managed by the government of Nepal. Nepal Electricity Authority(NEA) handled the major electricity production in Nepal and had control over macro hydropower to generate electricity. However, the electricity sector went through huge reforms when the government formed the Nepal Electricity Authority. Having said that, Despite Nepal being the second-largest nation in hydropower, due to various issues such as inefficiency in operation, supply interruptions, etc, the reform was unsuccessful. “While the initial reforms followed the standard ‘scorecard’ type of reform in developing countries (see Bacon, 1999); the model has largely proven unsuccessful in the Nepalese context” (Nepal and Jamasb,2011, p.2). Authors further add “ After nearly two decades of experience with electricity reform in Nepal; the current structure and organization of this hydropower dominated sector is regarded as being uncertain and unsustainable”(ibid).

In addition, a decade long revolution done by Maoist in the country delayed the reform process in the electricity. “Political instability has severely affected the predominantly state-owned sectors resulting in discontinued policies, uncertainty, and weak and often stalled implementation of reform”(ibid). As the energy sector is managed by the government itself, changes in political leadership and stability result in changes in plans and policies in the related field. Some private and foreign participation kept certain percentages of the electricity generation market, yet the nation could not achieve the result in electricity development through hydropower resources as expected. “The establishment of NEA eventually paved the way towards creating a legal framework and corporatization of the power sector through the

formulation of the hydropower development policy of 1992 and enforced by the Water [1] Resources Act and the Electricity Act with amendments made to the NEA Act of 1984"(ABD,1999, cited in Nepal and Jamasb,2011,p.5). The main objective of the policy was to encourage and promote hydropower development by enabling the government and private sector to develop hydropower electricity projects. The policy highlighted boosting electrification and its proper distribution in the rural area by small hydro plants and mass capacity installation.

The government of Nepal has attempted to increase and enhance the electrification in all areas of the country. Hence, many policies and laws were introduced. Among these was The Community Electricity Distribution Byelaws was initiated in 2003 and the target was to encourage public participation in minimizing power losses and institutionalizing distribution(Nepal and Jamasb,2011,p.7). Furthermore, the community electrification regulation was passed for the proper distribution of electricity in rural areas. In this reform, communities are also involved and were responsible for electric energy sales and distribution. The primary goals of electricity reform were the development of the energy sector, proper and efficient distribution, to entice private and foreign investment and to minimize the dependence on government support.

The state formed the policies such as the Foreign Investment and Technology Transfer Act 1992 which encourage foreign investment and the technical transfer to upgrade human and natural resources. Simultaneously, The Electricity Act 1992 was regulated to facilitate private participation in hydroelectricity generation. This policy provides the licenses to an individual or corporation to be involved in electricity generation, transmission and distribution about 1000 KW capacity. "26% of the total electricity was served by the private sector in 2010" (NEA,2010). Similarly," NEA has been facilitating the participation of the private sector through Power Purchase Agreement(PPA) to ensure meeting the energy demand"(Annual report; NEA,2018/19). Still, There are various regime actors (IPP: Independent Private Producers)who have a contribution to electricity generation however these are unhappy due to government regulations, inefficient policies and price subsidies in electricity consumption.

[1] The Water Resources Act of 1992 "provides appropriate legal arrangements for rational utilization, conservation, management and development of water resources"(Nepal and Jamasb, 2011)
The Electricity Act 1992 " was primarily promulgated to promote private participation in hydropower development"(Nepal and Jamasb, 2011).

"Rural electrification remains one of the major energy policy goals in Nepal"(Nepal and Jamasb,2011,p.12). Authors argue that the rural electrification is delayed due to improper distribution as well as poor infrastructures(ibid). The geographical locations and low power prices are some issues that the private sectors are not willing to make an investment in expensive grid extensions in the nation. Moreover, not being able to use its own hydroelectricity potential, Nepal also has to import electricity from India. Therefore, various policies and reforms have not succeeded due to the country's many issues and still, Nepal is vulnerable towards achieving its energy demand.[2]

Sector Status	IPP introduction	Independent regulation	Reform enacted	Structure of the market	Generation ownership	Networks ownership (transmission/distribution
	1992	1994	No	Vertically integrated, Functional unbundling introduced	Dominant state ownership	Completely state-owned

Table 5: Power sector reform status in Nepal

Source: Nepal Electricity Authority(2010)

Another problem in the energy regime in Nepal is uneven electrification in rural areas. And the people are mostly relying on traditional energy sources which include fuelwoods, biomass, and charcoal for energy usages for lighting and cooking(Barnes and Floor, 1996; WDR, 2010; WEO, 2006: Zahnd and Kimber, 2009, cited in Gurung et al,2013, p.1104). Because of technical and financial problems, Nepal is unable to use its full hydropower prospects to generate electricity and to make the country less dependence on traditional energy. " In terms of sector-wise consumption, the residential sector consumes a higher proportion of total energy in the country unlike in most developed countries where the industrial sector leads the national energy consumption"(Nepal,2012, cited in Gurung et al, 2013). As rural people are consuming solid

[2] Foreign Investment and Technology Transfer Act 1992 "was to promote and facilitate economy-wide foreign investment and technology transfer by making optimum use of natural and human resources in the transition towards industralisation" (Nepal and Jamasb, 2011)

fuelwood and Kerosene oil mostly for their day to day need for cooking and lighting. Authors further explain “there is considerable disparity in electricity distribution and consumption patterns between rural and urban areas, as the benefits of electrification are largely concentrated in urban areas.”(Nepal, 2012; Pandey,2009, cited in Gurung et al,2013,p.1105).

To summarize the analysis of this sub chapter, we found out that a considerable amount of changes have occurred in the electricity regime from the last two decades in Nepal since the electricity reform was declared. Policies and plans were developed for the production and distribution of electricity and to achieve the increasing demand for the country. Various small yet state-owned electricity firms integrated together and the Nepal Electricity Authority(NEA) was established to enhance proper energy management. Additionally, private sectors and foreign actors were encouraged to participate in electricity production, transmission and distribution. Also, communities were included through the Community Act to distribute and sell the electricity to reduce state reliant for power. Rural electrification was also an imperative policy on the energy policy by the government of Nepal. Although, many transformations happened, still numerous reasons such as political issues, improper implementation plans, government strict rules, and laws restricted the sufficient electricity generation from big hydropower projects.
A huge percentage of electricity is used in urban areas of Nepal and the government is unable to provide power in the rural areas. Merely 34% of the rural public had electricity facility in the year 2008 where in urban the percentage accounts for 90% of the electricity. Therefore the state initiated its steps to sustainable energy production methods and technologies to generate electricity from green resources available in the country(Gurung et al,2013,p.1105). We will analyze various renewable niche- innovations in Nepal below:

7.1.2 Electricity From Renewable Energy and Niche innovations

To achieve sufficient energy for the country, the government of Nepal has initiated various technologies to generate electricity from renewable energy sources and these technologies are Renewable Energy Technologies(RETs) which includes micro/mini-hydro. Solar, wind, and biogas and biomass.“Because of the country's inability to develop mega hydropower schemes, increasing dependency on imported energy sources, constant power shortages and increasing demand, development of a decentralized, affordable and efficient energy supply system have been impressive for the Nepalese energy sector”(K.C et al, 2011;cited in Nepal and Jamasb, 2011).Renewable energy production in Nepal not only considers the landscape pressures such

as climate change and high oil prices but also these sources will provide enough energy to fulfill the energy demand, if properly planned and implemented, resulting in equal and realistic distribution between urban and rural areas and also make less vulnerable to import traditional fossil fuel as required for the country.

As the household sector is the main consumer of electricity in the country which is 44% in 2017/18 compared to the industrial sector which has only 37.1% consumption share. Households use mainly solid fuel for their energy needs for cooking and then Liquified Petroleum Gas (LPG). “Energy consumption mix for the FY 2017/18 depicts high dominance of traditional fuels(68.9%)” (Annual Report: AEPC,2017/18). The major driving force that leads the government to focus on producing renewable resources is rural electrification. Renewable Energy Technologies(RETs) role to achieve the energy need of the rural area was known by the state around the 1980s in the Seventh Five Year Plan. From that time, the development of RETs was special attention to the government and are integrated such technologies in plans and policies. The country established the special center on Nov 3, 1996, known as the Alternative Energy Promotion Centre(AEPC) for encouraging and facilitating renewable energy technologies in Nepal(Annual report: AEPC,2017/18,p10). The directive of AEPC consists of the promotion of wind energy, solar energy, micro/mini-hydro, biogenetic gas and so on and it is recognized as a vital institution upgrading and promoting RETs in the country.

Evolution in renewable energy was started from 1985-1990 in the country, Nepal adopted alternative energy in its plan and policies to enhance alternative sources to produce energy in particular solar, wind and biogas and also promoted improved and efficient cooking stoves, water mills and water turbines(AEPC,2017/18). The government also embraced policy for participating private sector and grant loans to consumers for the successful promotion of these technologies. In 1990-1995, the eighth plan formed that stressed rural electrification from micro-hydro projects with the collaboration with the Agricultural Development Bank, private sector and NGOs. The tenth plan(2002-2007) arose to develop renewable technologies to advance economic development and to achieve a sustainable environment. “The plan also envisioned to commercialize alternative energy technologies and replace traditional forms of energy with modern energy sources”(APEC Annual report,2017/18). Similarly, “the Three Year Plan (2010-2013) adopted a long term vision of ensuring a long term vision of ensuring 10% contribution of renewable energy in the energy mix such that 30% penetration is achieved

among the population with access to electricity" (ibid). The plan embraced policies to provide energy through urban solar and waste. Likewise, The Thirteenth Plan (2013-2016) focused on RNDs and technology transfer of RETs(ibid). At the same time formed a policy to operationalize Central renewable energy fund, proper management of used batteries from solar technologies and for water pumping, wind and solar technologies used.

Besides, the government developed numerous policies and legal frameworks to promote and use renewable resources. The constitution of Nepal (2015) explains and ensures the government makes the policies to develop and promote renewable resources technologies and that policy verify and regulates the efficient use of energy and to achieve the energy demand of the people. Correspondingly, Rural Energy Policy, 2006, focuses on minimizing the use of traditional energy and environmental protection by expanding clean energy in the rural area. Another policy is climate Change Policy 2011 of Nepal, the main focus is to minimize Greenhouse Gas emission and use of clean alternative energy. One of the recent policies regarding renewable energy is RE Subsidy Policy and Subsidy Delivery mechanism(2016), "Focus on the utilization of Best Available Technology(BAT) and Reverse Auctioning(RA) in the promotion and installation of RE technology"(AEPC,2017/18). So the government provides subsidies in the installation of renewable energy technologies which is consumption based on electricity technologies. The Fourteenth periodic plan targets to provide 9% more of the population, the electricity from green energy such as hydro, wind and solar resources. The goal of the plan is also to promote 1.065 million of improved and efficient cooking stoves and 0.2 million biogas digester(ibid). In rural areas, people need energy for cooking and they use solid fuel and kerosene oil, hence Biomass Energy Strategy 2017, encourages biomass energy to fulfill the growing energy demand of the country. The strategy emphasizes on making biomass energy from agriculture, organic wastes, and forest residues, resulting in a sustainable cooking solution. At present, "The white paper of the Ministry of Energy, Water Resources and Irrigation(2018) presents the scenario of renewable energy in Nepal" (ibid). Currently, 3,6 million households are accessed with more than 55 MW of electricity from renewable energy. According to the AEPC report "The white paper has provisioned the policy to establish the challenge fund to develop the 100 to 500 kW solar energy in each local level"(2017/18).

Renewable energy technologies yield an abundance of opportunities in producing and improving energy systems, particularly in rural Nepal, if available renewable resources are

managed and utilized properly. “About 50 MW electricity can be generated from micro hydropower schemes, 2100 MW from solar and 3000 MW from wind(SWERA,2006; WECS, 2010). Moreover, the country has the capacity to develop about 1.1 million domestic biogas plants(SREP, 2011; WECS, 2010)”, cited in Gurung et al,2013,p.1106,). Although the share of clean energy is very low in the energy mix in the country, renewable technologies have a huge impact on rural Nepal. Improved Cooking Stove (ICS) are more efficient technologies for cooking in households than the traditional fuelwood. ICS has mitigated the solid fuel consumption by 50% and at the same time 80% reduction in indoor air pollution(ibid). The acquisition of ICS technologies has improved greenhouse gas emission conditions and also a reduction in carbon. ICS distribution at households and indoor air pollution free projects for the targeted group were successful in the FY 2017/18. “Achievement stood at 148.02% and 114.93% against the target of 10,000 MICS and 20,000 target households respectively”(AEPC, 2017/18).

The energy requirement for cooking is one of the major problems in Nepal. In urban cities, people are dependant on LPG, on the other hand, kerosene oil and firewood in rural areas for cooking. Therefore, biogas is one of the important renewable energy technologies and it has been proven effective technology for energy generation for cooking. According to the annual report of AEPC “AEPC largely targeted to implement domestic biogas plants along with urban, community, commercial and municipal biogas plants”(2018/19). AEPC has been assisting the application and execution of large size biogas plants and making the use of municipal wastes, animal dung and waste from agriculture. This technology also helps in minimizing greenhouse gas emissions and it has a higher percentage(78%) of carbon reduction prospects. Besides, In Nepal Biogas is the first Clean Development Mechanism(CDM) project and the technology succeeded to generate US$0.4 million revenue(K.C. et al, 2011, cited in Gurung et al, 2013).

Solar photovoltaic(PV) is another innovative technology that is widely used to generate electricity in both urban and rural areas of Nepal. However, especially in rural areas, solar energy is used for electricity and in urban areas for heating and lighting. The installation and performance of solar power technologies were over achieved in the (APEC,2017/18). Also, solar dryers, cookers, and water heating system also had an effective result. The reports show that the private sector had a more successful rate than the regional led solar technology implementation last year(Annual report; AEPC, 2017/18). Similarly, mini/micro hydropower

technology is another widely used and electricity generating renewable technology in the rural area in Nepal. Micro hydro projects(MHPs) are an important technology that covers a significant amount of energy need in rural areas. In the Fiscal Year 2017/18 was planned to generate 2200 kW of electricity from mini/micro hydropower, however many reasons only 1249 kW was produced(ibid). The progress shows 104% from the Government of Nepal, private sectors could not achieve the targeted production. Various reasons such as human resources, budget issues, and implementation problems give low outcomes than planned. In addition, Improved Water Mill (IWM) technology achieved a satisfactory result and 67.67% progress was accomplished. IWM was earlier led and implemented by Regional Service Centre(RSC), but later the private sector led the implementation of the program. This transition controlled and guided the efficient execution of the project(ibid).

To achieve an efficient and sustainable environment, recently Decision-makers, Non-government organizations, and researchers have expressed interest in energy transitions. And, it is argued that to accomplish the goal, the system transformation is an important action. The major niche-innovations are a vital tool in the Multilevel perspective to change the system(Geels,2007). However, transitions and innovation in the system also emphasize the possible prospects and barriers for renewable alternatives and viable policies to prompt them. Therefore, in the case of Nepal, the electricity regime has changed over time and shown improvements, various policies, and legal frameworks were enacted to achieve the increasing electricity demand in the country. As the energy system was governed by the state earlier, then the changes in the regime occurred when policies formed to involve private sectors and the foreign sectors in electricity generation.

To sum up, the state has been supporting the development of innovative technologies to generate electricity and other basic energy requirements through renewable energy technologies and these RETs are cooking stoves, mills, solar photovoltaic systems, wind turbines, mini/micro hydro technologies. The Government of Nepal had initiated renewable energy options in the early 1980s, the government established regulatory body AEPC in 1996 mainly to regulate renewable energy production and distribution effectively. AEPC is a novelty that supports innovation and provides subsidies for the promotion and development of renewable energy technology and also encourages other novelties or actors in renewable energy development. Additionally, the landscape pressure and global environment protection

schemes such as environment protection, fuel dependency, high oil prices, and in Nepal the necessity of the electricity mostly in rural areas, complete dependant in India for import and frequent oil crises, these reasons also made the government more attentive to produce alternative renewable resources in the country. The renewable energy technologies have produced satisfactory results in energy production through mini/micro hydropower, solar, wind, biogas and biomass technologies, yet due to various reasons such as political instabilities, financial problems, lack of human skills, progress is slow and inefficient and inadequate management and implementation leads to the country dependent on traditional and imported fuel to fulfill the energy demand.

7.2 Analysis of Institutional Paradigm in Nepal

The term institution in the energy transition has been defined loosely as the formal and informal rules within a society as well as the relevant organization which embodies these rules. According to North (1991), institutions are humanly devised constraints that structure human interaction at the political, economic and social levels, shape the incentive structure of an economy, create order and reduce uncertainty in exchange. In the general level institutional theory defines social structure such as rules, standardize, beliefs, values, and culture of the society and these elements shape behavior and pattern of the people and their communities that they belong to(Andrew,2015). The energy sector can be anticipated as a particular type of socio-technical regime comprising an assemblage of the institution which develops around the particular set of technologies and supports the development and use of these technologies(Smith et al,2005 cited in Andrew,2016,p217). The concept of the socio-technical regime recognizes that technology and society are not separate spheres of activity and policy rather are highly interdependent. It means that technology can determine behavior in societies and societies can make choices concerning technologies. Heybey and Murrell (1997) have concluded that , “the success of sectoral reforms on outcomes in any transition economy depends much more on the overall institutional framework than on short-term policies”. Institutional factors in the electricity sector influence and support the continuity of the reform process by providing the legal and regulatory framework. Such an institution includes the embedded culture, societal norms, professional networks, the educational system, and the environment for innovation. Bacon and Besant-Jones (2001) found evidence of country policies and institutions being positively correlated with reform while country is in danger being negatively related to the energy transition.

From an institutional economics perspective, institutions constitute two essential components: the institutional environment and institutional arrangement (Williamson, 1995). The institutional environment is concerned with macro-level which can be formal or informal while institutional arrangement focuses on micro-level governance mechanisms. The institutional arrangement of a country largely influences the institutional environment and includes five elements: legislative and executive system, the judicial system, administrative system, informal rules and social and ideological character of the nation. In the context of Nepal, it is evident that because of the poor institutional arrangement of the government policies and regulation has affected the energy sector and energy transition towards renewable energies in several ways. The country's institutional arrangements in the energy sector are vertically arranged according to sub-sectors, such as electricity, petroleum and coal, forest and renewable energy. At the national level, ministries delegate operational responsibilities such as tariff setting, energy distribution and infrastructure expansion to various departments within them. At the district and local levels, Village Development Committees (VDCs) and District Development Committees (DDCs), non-governmental organizations (NGOs) and community groups are active in extending energy services to rural communities. There are also over 14 multilateral or bilateral agencies working in the energy sector, including United Nations Development Programme (UNDP), Asian Development Bank (ADB), Danish International Development Assistance (DANIDA), European Union (EU) and the World Bank(UNDP,2007).

Institutional setup in the energy sector

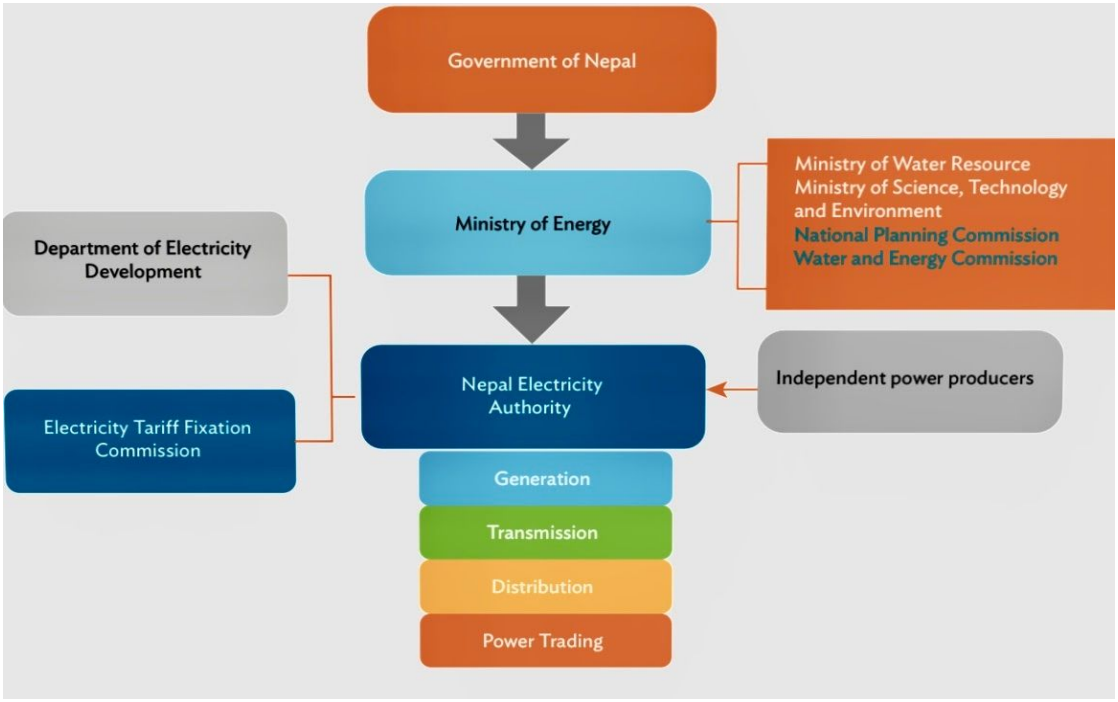


Figure 7: Institutional set up in the energy sector

Source: ADB,2017

In the energy sector of Nepal, the Ministry of Energy (MOE) is the apex body in the power sector which formulates policy, strategy and plan on the power sector (ADB,2017). The country has four levels of institutional arrangement: (i) policy, (ii) regulatory, (iii) operational, and (iv) implementation. The policy level institution includes the Ministry of Energy (MOE), National Planning Commission(NPC), Water and Energy Commission(WEC), Environment Protection Council(EPC). The energy sector is regulated by Electricity tariff fixation commission which review and approval of tariff applications submitted by the NEA. Department of electricity development (DOED) functions as the chief coordination unit for the promotion and development of the hydropower sector. It performs regulatory duties and responsible for providing licenses to hydropower projects. It is also responsible for developing policies and programs for the development of the hydropower sector(ADB,2017). Nepal Electricity Authority (NEA), Nepal Oil Corporation (NOC) and Alternative Energy Promotion Center (AEPC) are the major government agencies in the development of the power sector, imports and distribution of petroleum products, and promotion and development renewable energy technology respectively. The Nepal Oil Corporation(NOC), a state-owned trading company which is solely

responsible for importing, transporting,storing, and distributing all petroleum products in the country. Alternative Energy Promotion Center (AEPC), Ministry of Environment, Science & Technology (MoEST), is solely responsible government agency for the promotion of renewable energy in the country.

Nepal Electricity Authority(NEA) is a publicly owned vertically integrated organization that is in charge of the total supply chain of power from generation and transmission to distribution. There is no independent regulatory body in the power sector, though a bill is still pending for the formation of an independent regulatory commission. The monopoly ended due to two events: first, the Hydropower Development Policy enacted in 1992 established a liberalized market framework for hydropower development, which allowed private sector developers to enter and participate in electricity generation. The second event was the Community Electricity Distribution By-Law of 2003 facilitated the entry of third parties into retail electricity distribution, particularly in the form of communal utility enterprises such as rural electric cooperatives and other community associations(The Asia Foundation,2014,p2). The main aim of this law was to promote public participation in reducing non-technical power losses, institutionalizing distribution, and encouraging community management in the extension of distribution lines to promote rural electrification. However, even after two decades, the outcomes seems to have contradicted the objectives of the energy transition. The current structure and organization of the hydropower dominated sector is regarded as being uncertain and unsustainable. The vertically-integrated system has developed only around 0.72GW out of potential 40 GW of generation capacity including the IPPs' generation indicating lack of investments in a generation while the peak demand is projected to further increase to 2206 MW by 2020 and 3679 MW by 2030 (NEA, 2010). Electricity prices remain too low to cover costs or support system expansion and suffer from persistent cross-subsidization among domestic and industrial customers. The price-cost gap has affected the financial condition of NEA with an overwhelming loss of NRs. 4681 million in 2009(Nepa and Jamasb,2014,p15).

Even though the generation segment is open to private investors, barriers to entry still exist in terms of discriminatory network access to independent power producers. NEA as a state-owned single buyer tends to favor its own electricity generation thus distorting competition and discourages new entry. Therefore, Non-integrated private firms are unable to compete for consumers in the market. Eliminating entry barriers in terms of nondiscriminatory network

access can spur a private generation to meet the growing electricity demand. After nearly two decades of experience with Distorted electricity tariffs, low access rate, frequent supply interruptions, and inefficiency in operation have been the trademarks of the Nepalese electricity sector. This kind of Vertical institutional set-up structure in the energy sector reveals that the whole energy sector does not come under the purview of one organization but is dispersed in various ministries and the coordination among them is one of the major problems being faced in the country for the integrated energy policy, regulation and development aspect.

The centralized decision-making system in Nepal creating bureaucratic hurdles in maximizing the use of renewable energies in all over the country. In the energy sector of Nepal, for fully implementing renewable energy it has to fulfill various legal frameworks such as Rural Energy Act, Central Rural Energy Fund Regulation and Rural/Renewable energy central coordination Commission Regulation. This legislation and regulation are at different stages of development and considering the present political situation of the country which is not certain and stable at the current situation(Gurung et al,2013,p1107). The energy sector in Nepal is regarded as being 'resource rich but policy poor'. The political leadership changed 11 times in the last decade with Nepal being the world's most recent republic in 2008. Political instability has severely affected the predominantly state-owned sector resulting in discontinued policies, uncertainty, and weak and often stalled implementation of reform (Nepal and Jamasb,2011,p7).

Monopoly characteristics of the industry coupled with high politicization of the sector imply that the electricity transition makes it important to the economic growth policies in Nepal. Apart from that, in the institutional setup of the energy transition towards renewable energy APEC is the sole governmental agency that promotes Renewable technologies (RETs) through subsidy. Due to the limited number of agencies, there is a weak comprehensive integrated planning system in the districts and villages(Gurung et al,2013,p1107). Moreover, energy technologies have not received much coverage in most of the engineering and technical courses as there is no technical/vocational school that trains manpower in various ways. In addition, the country lacks investment in the R & D.Lastly, Nepal's RETs sectors are highly dependent on donor-funded programs as installation of RETs proved to be costly as compared to traditional fuels and the project is much more expensive because of the geographical condition of the country.

It can be analyzed that in Nepal policy paradigm govern the whole energy sector by involving state ownership of major energy companies, state control of energy pricing and administrative policy instruments to change actors' behaviors. In the pace of deploying renewable energy in Nepal, the resistance arises from the investment not just in physical assets but also from the political assets. The dominance of the political policy paradigm of Nepal is likely to limit the effectiveness of the renewable transition. It showcases that the role of the institution is highly dependent on the prevailing political regime, availability of financial and human capital of the country.

When analyzing the institutional pillars (regulative, normative, cognitive),these pillars support and build up the structural paradigm, regulative pillar help to make rules and regulations for future development, normative consists of values and norms that facilitate the right direction to the system and the third pillar is cognitive which promote the interaction between actors for further development. In Nepalese institutional paradigm, especially in the energy system, if the government formulate rules and regulations for enhancing renewable technologies(as regulative pillar), where normative pillar can define the norms and values to promote these technologies through obligatory action to social life. Finally with the help of the third pillar the cognitive, the government can open door for interaction with other actors in the system.Therefore, the institutional pillars support and establish relationships between various aspects of the system to facilitate new action.These three mechanisms function differently in different societies as respective rules, regulations, norms and symbols(Carvalho et al,2017,253).

7.3 Analysis of social innovation

The transition towards low carbon emission or renewable energy systems cannot solely depend on technological innovation but also requires social innovation. In the context of the energy transition, social innovation can be defined as an innovation that is social and contributes to low carbon emission transition, civic empowerment and social goals pertaining to the general well-being of communities (Hoppe and De Vries,2018,p13).In the energy transition, social innovation seeks to find an innovative solution to social problems in a community that are not met by the local system. Social innovation can induce social change and invent new alternatives for social interaction and practices.Social innovation processes analyses society's structural adjustment abilities to accommodate new ideas and practice. Social innovation manifested in

changes of attitudes, behaviour, or perceptions, resulting in new social practices(Cajaiba-Santana,2014,p45)

As the case of our study in Nepal, it has been facing an unprecedented energy crisis for the last two decades. A large section of people are deprived of the electricity in spite of this country has huge potential in hydropower, particularly rural areas. About 63 % of Nepalese households lack access to electricity and depend on the oil base and traditional biomass products and renewable energy(Banerjee et al,2011,p1). There is a huge difference between electricity consumption in urban areas and rural areas. The disparity in access starks with almost 90 % of the urban population while 30% in the rural population(ibid). The geographical condition with rugged terrain and economic feasibility has been causing hindrances in the electricity distribution through grid technology in the rural community in Nepal. Due to the poor service and poor energy production, the citizen has to suffer from 11-16 hours blackouts during the day. For resolving the energy crisis and promoting energy issues, the Government of Nepal by establishing APEC, decentralized electricity services in the form of off-grid and mini-grid renewable technologies.

The electricity crisis has been seen as a challenging wicked social problem in Nepalese society. To combat energy scarcity, the Nepal Government has prioritized renewable technologies(RETs) as a novel innovative approach. As social innovation is an effective approach to responding to social challenges, by mobilizing people's creativity to develop solutions and make better use of scarce resources (BEPA 2010: 7).Renewable energies are drivers for Social Innovation, which is friendly to the environment has the potential to increase the social and economic opportunities of Nepal at the local level and help in improving people's livelihood. Renewable technologies can be a means of developing a sustainable rural energy system and thereby achieving sustainable livelihoods. The implementation of renewable energies through social innovation approach, the GoN through APEC and NGO like UNDP, World Bank has given focus to electricity generation through micro and mini-hydro, domestic, urban and commercial biogas plant installation, Solar drinking water and pump installation program for irrigation purpose, institutional solar energy system, wind energy project in public-private partnership, solar rooftop, and grid-connected solar promotion program and extensive support to areas lacking electricity belonging to Province 2, Karnali Province and Sudoorpaschim Province of Nepal(APEC 2018/19). The GoN is looking forward to transforming

its energy sector towards more Green and efficient energy through innovative approaches in renewable technologies in society.

When regarding social innovation's contribution to the energy transition it issues a number of key issues in society. Firstly technological innovation leads to new market models, actors and institutional settings creating room for social innovation. In the energy transition, Social innovation makes a new governance arrangement and aid to create community energy, provide socio-economic impact and implication, and social incentives and policy to empower it(Gues and Wittmar,2019). However, there is no specific tool to measure the outcome of the social innovation approach. The success of innovation depends on the social-economic impact of implemented technology on the community. The dissemination and promotion of Renewable technologies solutions in Nepal have had a substantial impact on the quality of living at the local communities in rural and remote areas. Correspondingly, cross-sectoral implementation in health, education, water treatment, public services, and other productive end-users has greatly enhanced livelihood improvement of the local population.RETs have also provided different kinds of opportunities for men and women in terms of exposure to new technologies, although there have been very limited opportunities for women to be involved in social and economic activities for their self-enhancement and empowerment(Mahat,2004,p11).

Although the share of renewable energy is less than 1% in the national energy mix, RETs have a significant impact on the rural communities. Traditional solid biomass burning stoves have a low heating efficiency of 5-10% compared to that of the improved cooking Stove(ICS)(Gurung et al,2013,p1106).In addition, usage if ICS helps to reduce firewood consumption by 50% and air pollution by 80%(AEPC/ESAP,2012 cited in Gurung et al,2013). Moreover, the Adoption of ICS can achieve greenhouse gas(GHG) emission reduction by1.2tCO2 CO2 equiv/plant/year and has a carbon mitigation potentialof8.34%(Ibid). Biogas is another RET that has made a direct impact on health and agricultural production. The use of biogas has reduced the labor of the rural population, especially for women, since they are responsible for handling household chores and collecting firewood for cooking(Ibid). Further, the end product of biogas which is bio-slurry can be used as natural fertilizers for better agricultural. Solar photovoltaic(PV) and micro-hydro are widely used for electrification in Nepal. Installation of both RETs has reduced women drudgery, consumption of firewood, consumption of fuel (Kerosene) and improved sanitation and environmental condition(Ibid). The RETs sector has also created employment

opportunities for the rural population by running a small enterprise and providing jobs to the local community.

The reason behind the poor implementation of renewable energy technologies is weak monitoring and evaluation aspects of rural energy plans and programs. There is not enough emphasis on regular monitoring and evaluation activities so as to ensure the better implementation of renewable technology. The Rural development initiatives in Nepal are still focused on the technology rather than the community and on supply rather than demand. Thus, energy investment and subsidy programs have been ineffective in addressing the issues related to community development and poverty alleviation(Mahat,p8). Although recent developments in rural energy planning are focused on a bottom-up approach so as to follow the pattern of decentralized governance, the planning practices still remain top-down In the energy transition, social innovation strongly focuses on bottom-up initiatives by engaging the community in the transition. However, Planners and policy-makers of Nepal have not focused properly on the needs and priorities of the local community, and they have practically ignored gender issues (ibid). Energy sector policies seem failed in the inclusion of gender from both strategic and practical points of view. No priority has been given to the specific users (i.e., women) while promoting AETs, nor have women been encouraged to participate in planning rural energy programs. Thus, they have not addressed the importance of gender roles in the energy sector and the involvement of women in energy development programs(ibid). Another main reason behind the sluggish development of RETs in Nepal is subjected to various barriers such as long-term financing options, the low purchasing power of the rural community, inadequate and collaborative efforts with the donors and lack of privatization.

7.4 Compilation of the Results

To sum up, Nepal can implement renewable energy in order to deal with the energy crisis that they are currently facing. This country has an abundant renewable energy source and they can research the innovation happening in renewable energy. This country should focus on the community-based initiative otherwise the social innovation can not be successful in the long term. Innovation does not solely focus on the local or ‘niche’ level but also acknowledges the system or ‘regime’ level, which contains elements (like institutions, social structures, and

incumbent actors) that strive to maintain the status quo and often form barriers to social innovation and the transformative change it seeks to incur (Hoppe and Vries,2019,p4). In the scenario of Nepal, community-based initiatives are arising from a niche level and this grassroots initiative has the power to transform the whole regime of the nation This renewable energy has the power to transform the policy of the county in order to alleviate poverty, reduce dependence on traditional fuel, development of the rural area and handling the issue of climate change.

Therefore, we studied and analyzed the existing energy regime and new innovative technologies that have been adopted and used to produce energy from renewable resources in Nepal, we found out that many reforms and changes in energy policies have been embraced by the government of Nepal from the 1980s to achieve the energy demand. As we have mentioned above also that Nepal has ample natural resources and the right geographical locations to generate sufficient energy from renewable resources, for instance, solar energy because most of the months the climate of Nepal is intense sunny, enough water sources for hydroelectricity and mountains for wind energy. So if managed and installed properly, renewable energy technological possibilities and opportunities are higher for energy production. Hence the country has the huge technological potential to produce energy, we have shown the technology potential table in the empirical section in the Methodology chapter. These technologies capacity are Improved cooking stoves(>2.5 million), improved water mill (25000-30000 MW), solar photovoltaic system (2100 MW), wind turbines(3000 MW), biogas(1.1 million plants) (AEPC annual report, 2017/18). In addition, introducing and implementing these technologies will play an important role in social innovation, especially in the rural sector, since the energy distribution is a very imbalance between urban and rural areas. Rural electrification is one of the major social innovations where most of the area is experiencing no electricity even for daily basic needs. Similarly, Adequate electricity for lighting and improved cooking stoves will enhance the health and quality lives, and also, green energy technologies will be the medium of income generation which will eliminate poverty in rural areas and enhance the quality of life.

Despite having several possibilities at technological and social innovations, yet the country is unable to implement these technologies efficiently to produce sufficient energy. While analyzing the data, it showed that the country has succeeded to introduce and install several technologies to produce energy from renewable resources but due to various barriers or challenges at technical and societal levels, the smooth operation of these technologies is distributed and not

proving the results as expected. The different kinds of barriers exist such as policy barrier, these barriers consist of a rigid legal framework, ineffective policies, corruption, and other administrative obstacles. Another barrier if financial barrier, new technologies, and projects require high investment and due to insufficient fund, these projects depends on donor funds. Furthermore, Barriers and challenges at technological and societal levels mainly create more problems in implementing RETs. Technical hurdles constitute a lack of technical knowhow and maintenance, poor infrastructure, lack of R&D initiatives and other environmental issues also create problems in technical aspects. Similarly, a societal level, the local public oppose the installing and operating process of RETs, due to lack of knowledge of the positive outcome of these technologies in their lives and also because, for instance, the public needs water for their basic needs and for irrigation first rather than hydropower projects. Besides, Socially and politically influenced local communities to resist the operation and implementation of RETs, if other political parties are operating the projects. These challenges and barriers largely interrupting new technology development in the country.

Even as fuel crisis and fuel dependency are major issues for Nepal that consistently making the country more vulnerable and affecting the overall economic growth since energy plays a vital role in the development of the nation. The government of Nepal is initiating RETs to overcome the fuel dependency and fuel crisis through proper planning, by making effective policies and legal frameworks and also through involving the private sector, foreign sector, and local communities in the development of these technologies that will result in an increase the green energy production and proper distribution. The government has established the Alternative Energy Promotion Centre(AEPC) and its primary goal is to initiate renewable energy production and promotion of RETs. Although the government sought alternative energy sources long ago, therefore, the state had already initiated renewable energy sources since the 1980s. Now the energy demand is increasing, the government has been more attentive towards renewable energy technologies and hence been making plans and policies to enhance these technologies to produce and distribute the required energy for the country. As we see from data collection, the government has embraced the policies to promote RETs; biogas plants, improved cooking stoves, Watermills, and water turbines and these policies include granting loans to encourage consumers and also providing subsidies. Correspondingly, the government is emphasizing on the development of technical manpower for smooth operation (AEPC, 2017/18).

To increase the energy production the state has encouraged the involvement of the private sector investment and NGOs, INGOs for R&D purposes. Rural Energy Fund is also one of the important steps to grow district and rural areas to achieve the target. Likewise, urban solar and waste materials to energy projects have been planned for commercialization. The government is focused on the proper balance between demand and supply of energy to accomplish the basic needs of people. Another important policy that the government has initiated to promote RETs is "RE Subsidy Policy and Subsidy Delivery mechanism(2016) focused on the utilization of Best Available Technology(BAT) and Reverse Auctioning(RA) in the promotion and installation of RE technologies"(AEPC annual report, 2017/18). As we can see, the government has initiated several plans, policies, legal frameworks to promote renewable energy technologies to produce sufficient energy and to overcome the fuel crisis in the country. The state has somehow recognized the opportunities and succeeded to achieve the target to some extent(We can see the data in the empirical section in methodology) and producing energy to fulfill the demand, still, there are a huge amount of barriers and challenges that are consistently occurring and causing disturbances in implementation of RETs and to achieve the expected results. The effective and efficient deployment of renewable energy technologies can help to generate energy for the country and overcome the country from fuel crisis and fuel dependency.

8.Discussion

In this chapter, we will discuss the energy transition and use of the socio-technical approach in the context of Nepal and will compare its uses in other countries. Likewise, we will explore more on how the government can overcome the energy crisis by weakening the regime level and can enhance niche innovations.

The purpose of this thesis was to investigate the transition in the energy system in Nepal from traditional sources to renewable energy to overcome the fuel crisis and the energy dependency and the government's role in promoting renewable energy technologies to fulfill the energy demand in the country. We discovered that the government has introduced numerous plans and policies to make energy production and distribution more efficient and effective from both courses of action; mega hydropower and renewable technologies such as solar, wind, biogas, and mini-hydropower, however, consistently existing barriers and challenges, mainly political, technical and social levels, fail the proper implementation of projects and the government would not be able to produce adequate energy as expectation. Although the government has initiated

many transformations in the energy sector since the 1980s and equally adopted alternative technologies and comparatively it has been successful to achieve its goals, especially in rural areas.

Correspondingly, our main aim was to study the socio-technical approach into the energy transition through the multilevel perspective, which defines the interaction between the three levels, the existing institutional structure, innovation, and the external forces. These three levels navigate and support the transition in the system(Geels et al, 2017,p,1242). According to the collected data, the government of Nepal facilitated many changes in the energy system(as the state was solely governing the energy system) for example,public-private partnership, formed policies to attract foreign investors involved local communities, and also commenced alternative energy sources, yet due to its rigid and monopolists structure, changes are ineffective. Therefore, the socio-technical approach could be a very useful tool for the country to bring a successful energy transition as it focuses the interaction, teamwork and involves multi-dimensional development not only emphasize the existing system but also focuses on innovation and transformation through support at different levels. “Sociotechnical transitions gain momentum when multiple innovations are linked together, improving the functionality of each and acting in combination to reconfigure system”(Geels et al, 2017).

On the one hand, the government claims that it has led to effectual changes in the energy system to produce the required energy for the country(Nepal and Jamasb, 2011). On the other hand, the state-owned system, monopoly, and complicated rules and regulations have been preventing the development of the sector. The regime level(as in the socio-technical system) resist changing in the case of Nepal. Although the landscape pressure such as fuel crisis, energy dependence put pressure on the regime to destabilize to make new opportunities for niche innovations, the rigid administrative control prevent the sector to advance. Geels explains the sociotechnical transition do not come simply since many established systems are preserved or stabilized by lock-in mechanism (2010,p.495). These lock-in mechanisms can be political biasedness, vested interests, favorable regulations, and subsidies. The niche innovations in the energy system are renewable energy technologies(RETs) and these technologies are relatively helping the Nepalese energy sector to produce energy that is widely covering rural areas of the country. The government has broadly promoted these technologies by involving the private sector, the foreign sector, and local communities. Hence, when we see MLP levels in the

socio-technical system, in the case of Nepal, all three levels exist but are imbalanced, the sector lack interaction and support within and between these levels.

In addition, reviewing the social-technical approach, we identified many successful cases, at the same time, some cases were dissatisfied with the approach due to their respective issues. Mostly, the developed nation shows better results in the energy transition such as Germany, Denmark, these nations have successfully embraced the energy transition from black to green energy, whereas the developing and least developed countries struggle to adopt effective energy transition, due to several challenges and barriers at policy, technical and societal levels. For instance, energy transition in the case of Nigeria, the country is abundant with natural resources, wind, solar, hydro resources to generate renewable energy, however, state-owned and rigid energy systems, political influences, financing, and technical know-how, these issues have highly affected the energy transition in Nigeria(Osunmuyiwa et al, 2017,p.149). Similarly, Nepal faces the same problem, the energy system is highly influenced by rigid policies and regulations.

In contrast, some authors have criticized the MLP saying that the socio-technical approach gives more emphasis to green niche innovation and lacks perceptive to power and politics. The energy regime widely affected by politics and power in Nepal because the sector is operated and managed by the government itself. Several authors argue that “the lack of explicit attention for power and politics that underpin the development and implementation of specific policies(Smith et al., 2005: Meadowcroft, 2011, cited in Geels, 2014,p.24). In MLP, the stability in regime is considered automatic, however, researchers argue that stability is the result of incumbent actor’s resistant to change in the system. Our main focus is analyzing the development of niche innovations, yet these innovations are extensively influenced by the existing regime in Nepal which is broadly affected by power and politics. Though in this paper, we did not go in depth analysis of politics and power and our primary focus was the new technology development in the energy system to overcome the fuel crisis, still, the enhancement of these RETs is determined by the regime level in Nepal. As we realized the success of the socio-technical approach mostly in developed countries because regime levels and institutional structures are well defined and functional in industrialized countries, unlike developing countries where the system could not even able to fulfill the basic energy needs due to various rooted problems at political, technical and societal levels.

Although the energy regime is complex in Nepal, yet the sector has embraced innovative technologies as renewable energy technologies(RETs). Owing to the number of challenges and barriers, energy efficiency is very low. Political instability, community resistant and priorities, lack of trained manpower, lack of finance, poor infrastructure, etc have limited the production of green energy. The data collected express the potential of Nepal but the achievements are not satisfying. Having said that, we can debate many opportunities also since renewable technology projects have been succeeded as well in many cases, for example, Improved Cooking Stoves(ICS) and Improved Water Mills (IWM) and solar for lighting, since these are the basic daily energy needs in the country. RETs have significantly covered the rural area, the lives of rural people have improved by these technologies. Therefore, rural electrification is an important aspect of social innovation in Nepal. We can discuss that, these innovations are the imperative strategies of the government of Nepal to overcome the energy shortage and to reduce fuel dependency. According to the data, 83% of people live in rural areas and if these alternative energy technologies can produce the necessary energy and fulfill the basic energy need, then we can say that RETs if implemented properly can fulfill the energy demand of the country.

The socio-technical approach can be a successful approach to achieve energy efficiency in Nepal if the three levels in multilevel perspectives interact and support within to bring a new standard in the system. “A number of sustainability transitions scholars agree that at the heart of the transitions debate are governmental relations with other actors”(Osunmuyiwa et al,2017,p.145). Authors further elaborate “there is increasing knowledge that the governmental policies are needed to provide ‘shielding’ or ‘nurturing’ spaces for niche technologies(Raven, Kern, Verhees, & Smith, 2015) “ibid”. Therefore, the government can promote policies that encourage other novelties or actors who support niche innovations. The regime should weaken to decentralize and open the opportunities for innovation. From the findings, we identified that if the government discover new strategies and set favorable regulations to promote and encourage the development of renewable technologies along with other actors, by making efficient pricing policies, providing subsidies and loans to promote these green technologies, the state can produce and distribute sufficient green energy and can overcome the fuel crisis. Besides, the government can develop niche technologies by managing and tacklings its challenges and barriers accordingly for proper installation and implementation of new technologies.

To summarize, the energy transition from traditional sources to renewable sources can be an important innovative step to produce and distribute the energy in Nepal, however, a number of barriers and challenges prevailing in the country are causing inefficiency in the proper production and management even after many reforms and changes the government has declared and implemented. The socio-technical approach can be an important tool in case that the integration and interaction between the three levels in MLP are well understood by the government to adopt this approach just as adopted by many developed nations from black to green transition. The government of Nepal affirms many transformations in the energy sector by partnering with private sectors and foreign sectors, yet, the stable and rigid structure of the energy regime is preventing the smooth operation of such changes. We also discussed that the socio-technical system should also recognize the political and power aspects in its regime level since many developing countries are mostly affected by such issues. Additionally, the state has to develop healthy relations with other actors who are interested to promote and invest in these technologies so that the government can produce adequate energy from the available renewable resources and able to overcome the energy crisis and reduce fuel dependency.

9. Conclusion and Recommendations

To control the fuel crisis and to reduce fuel dependency, the government of Nepal has commenced the alternative renewable energy technologies(RETs) to produce the required energy for the country through the Alternative Energy Promotional Center(AEPC). The center promotes renewable energy and encourages private and foreign sector participation in energy production and distribution. From the data analysis, it can be seen that the government has installed these technologies in urban areas and mostly in rural areas. These technologies are Improved Cooking Stoves, Improved Water Mills, Solar Photovoltaic system, wind turbines, mini/ micro hydro projects. In urban areas mostly solar panels are installed for heating and lighting and other technologies are implemented in the rural areas for cooking, lighting, and for other basic energy needs. Renewable energy technologies have immensely improved the daily life of people in rural areas.

Even though the government had initiated the alternative energy production process early in the 1980s, however, due to various consistently occurring barriers and challenges, the government has succeeded only to produce very low percent of renewable energy and is unable to generate

the required energy and the country become more vulnerable to the energy which results in regular fuel shortage. According to the findings, the government has declared several plans, policies, regulations and legal framework for the transformation in the sector, yet these barriers and challenges occur at political or policy, technical or environment and societal levels significantly affecting the production and distribution of the energy. Data shows the country is rich in natural resources and its suitable climate also opens up more opportunities to produce sufficient renewable energy.

An energy transition is an important tool that many developed and developing countries have embraced to make the transition from black to green energy. These countries have adopted energy transition, for example, coal to green transition in Denmark, electricity transformative policies in Germany, sustainability transition in the Netherlands and also in developing countries such as the energy transition from fuelwood to Liquified petroleum products(LPG), green energy transition in Nigeria, etc. We have found that the energy transition possesses many challenges and also offer many opportunities, however, for developing countries, the government or the energy producers have to tackle many issues such as poverty, political instability, technical and societal challenges.

The socio-technical framework has been used to analyze the transformation and new technology development in the energy sector in Nepal that helped us to discover the three levels of MLP, especially the regime and its changes ,and niche innovation that the government has adopted to enhance the energy production such as reforms in plans, policies, regulations and has promoted renewable energy technology in the country. We discovered that the energy regime in Nepal is rigid and complex as the sector is operated by the state and the monopolist nature of the regime level is more focused on vested interest and favorable regulations. The country is regularly experiencing landscape pressure such as fuel crisis, fuel dependency and because of these issues, the government has promoted niche innovations as renewable energy technology(RETs). Despite these innovations, the government is unable to produce sufficient energy from these technologies due to its complicated system and rigid rules and regulations, and also unable to attract other actors.

Furthermore, the socio-technical approach can be a useful approach to the energy sector of Nepal to produce adequate energy for the country. The interaction and coordination between

the three levels in the multilevel perspective(MLP) the landscape level, the regime level, and the niche level can help the government to implement renewable energy technologies efficiently to produce and distribute the required energy. The landscape pressure weakening the regime level and then flexible regime open up the new opportunities for niche innovation together with other novelties. Similarly, the government has initiated the AEPC as a novelty for promoting niche innovation and it provides loans, subsidies to promote these technologies including both urban and rural areas. We found out that with the advancement of these technologies the state has attempted to overcome the regular fuel crisis, however, consistently occurring challenges and barriers prevent energy production.

To answer the research question, it can be concluded that the government of Nepal has initiated various renewable technologies to overcome the fuel crisis and fuel vulnerability. These technologies have extensively upgraded the quality of life, especially in rural areas. The government has encouraged decentralization of the sector by involving other interested actors such as private and foreign investors and also local communities in sales and distribution of the energy. The country is affluence with natural resources, hence there are a number of technical and social innovations that are possible to enhance the energy sector, however, several obstacles existing in the country are hampering the technology implementation that results in inefficient and ineffective production and distribution in the sector.

Therefore, in relation to the socio-technical system, we recommend that the government should embrace the practice of the multilevel perspective and the interaction between the three levels to enhance the effectiveness of renewable technologies. When the landscape level put pressure, the approach helps the regime level to be flexible that encourage new opportunities and niche innovation. We can see the government has implemented RETs, but it lacks how the system and innovations interact and support each other with other actors for sector development. Additionally, the government can promote decentralization and perfect competition market , formulate rules and regulations, a legal framework that would encourage private sectors without biasedness and could attract the foreign sector. Moreover, we recommend the government to focus more on barriers and challenges since these aspects are hindering the development of renewable technologies. The government can tackle these issues through increasing awareness at the societal level, by removing the monopoly in the energy sector and keeping it out of political issues, by increasing R&D initiatives and by providing

training to increase the technical know-how. We have found that the government has provided subsidies to companies that sales traditional resources, instead the state can provide more subsidies to renewable technologies development so that the government can produce and distribute sufficient energy from these technologies and overcome the fuel crisis and dependency.

10.References

ADB. (2015). *Energy Outlook for Asia and the Pacific. Manila*: Asian Development Bank.

AEPC (2018),*Progress at glance: A year in review FY2074/75(2017/18) ,*Alternative Energy Promotion Center available from : https://www.aepc.gov.np/uploads/docs/progress-at-glance-a-year-in-review-fy-207475-201718-1541497047.pd

Andrews-Speed, Philip(2016). "Applying Institutional Theory to the Low-Carbon Energy Transition." *Energy Research & Social Science*, vol. 13, no. C, pp. 216–225., available from doi:10.1016/j.erss.2015.12.011.

Auvinen, Heidi & Tuominen, Anu (2014) Future transport systems: long-term visions and socio-technical transitions. *European Transport Research Review*. Volume 6 (3), 343–354. Available from DOI: 10.1007/s12544-014-0135-3 accessed on 15 November 2019

Aylesworth, G. E. (1991). Dialogue, text, narrative: Confronting Gadamer and Ricoeur. In H. J. Silverman (Ed.), Gadamer and hermeneutics (pp. 63-81). New York: Routledge.

Bacon, R.W. and Besant-Jones, J. (201). Global Electric Power Reform, Privatization and Liberalization of the Electric Power Industry in Developing Countries, *Annual Review of Energy and Environment*, Vol.(26), pp. 331-359. Available from: http://search.proquest.com/docview/219849608/.

Banerjee, Sudeshna Ghosh; Singh, Avjeet; Samad, Hussain. 2011. Power and People *: The Benefits of Renewable Energy in Nepal. World Bank Study. World Bank.* available from: https://openknowledge.worldbank.org/handle/10986/2340

Barrett, Frank & Powley, Edward & Pearce, Barnett. (2011). Hermeneutic philosophy and organizational theory. *Research in the Sociology of Organizations*. 32. 181-213. Available from 10.1108/S0733-558X(2011)0000032009.

Bergman, N., Markusson, N., Connor, P., Middlemiss, L. and Ricci, M., 2010. Bottom-up, social innovation for addressing climate change. *Energy transitions in an interdependent world: what and where are the future social science research agendas*, pp.25-26.

(BEPA), 2011. *Empowering people, driving change Social Innovation in the European Union.* Bureau of European Policy Advisers

Bryman. A and Burgess.R.G 2002 " Analyzing Qualitative Data" London and Newyork.

Cajaiba-Santana, Giovany (2014) Social innovation: Moving the field forward. A conceptual framework. *Technological Forecasting & Social Change*. volume 82 (C), 42–51. Available from DOI: 10.1016/j.techfore.2013.05.008 accessed on 18 November 2019

Carvalho, Andriele De Pra, et al.(2017) "The Role and Contributions of Sociological Institutional Theory to the Socio-Technical Approach to Innovation Theory.(Texto En Ingles)." *RAI Revista De Administracao e Inovacao*, vol. 14, no. 3,, p. 250., Available from doi:10.1016/j.rai.2017.02.001.

Coelho, Suani Teixeira et al. (2018) The energy transition history of fuelwood replacement for liquefied petroleum gas in Brazilian households from 1920 to 2016. *Energy Policy.* 12341–52. Available from https://doi.org/10.1016/j.enpol.2018.08.041accessed on 20 November 2019

De Geus, T. and Wittmayer, J., 2019. Social Innovation in the Energy Transition. Examining diversity, contributions and challenges. Scoping workshop report. Cambridge: Energy-SHIFTS.

Gadamer, H. G. (1975). *Truth and method.* London: Sheed & Ward.

Geels, Frank W.(2004) “From Sectoral Systems of Innovation to Socio-Technical Systems: Insights About Dynamics and Change from Sociology and Institutional Theory.” *Research Policy* 33.6,: 897–920., Available from doi:10.1016/j.respol.2004.01.015.

Geels, Frank W.(2010) “Ontologies, Socio-Technical Transitions (to Sustainability), and the Multi-Level Perspective.” *Research Policy*, vol. 39, no. 4, pp. 495–510., available from doi:10.1016/j.respol.2010.01.022.

Geels, Frank W, et al.(2014) “Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective.” *Theory, Culture & Society*, vol. 31, no. 5,, pp. 21–40., available from doi:10.1177/0263276414531627

Geels, Frank W, Sovacool, Benjamin K, Schwanen, Tim and Sorrell, Steve (2017) Sociotechnical transitions for deep decarbonization. *Science*, 357 (6357). pp. 1242-1244 http://search.proquest.com/docview/1942676004/.

Godwill, Engwa Azeh. (2015) *Fundamentals of Research Methodology : A Holistic Guide for Research Completion, Management, Validation and Ethic*s. New York: Nova Science Publishers, Inc. available from https://soeg.kb.dk/ accessed on 9 December 2019

Gurung, A., Karki, R., Cho, J.S., Park, K.W. and Oh, S.E., 2013. Roles of renewable energy technologies in improving the rural energy situation in Nepal: Gaps and opportunities. *Energy Policy*, *62*, pp.1104-1109.available from 10.1016/j.enpol.2013.06.097.

Guzys D, Dickson-Swift V, Kenny A, Threlkeld G. Gadamerian philosophical hermeneutics as a useful methodological framework for the Delphi technique. *Int J Qual Stud Health Well-being*. 2015;10:26291. Published 2015 May 5. Available from doi:10.3402/qhw.v10.26291

Hazeltine, A., Pel, B., Wittmayer, J., Dumitru, A., Kemp, R., Avelino, F., and Haxeltine, A., 2017. Building a middle-range theory of transformative social innovation: Theoretical pitfalls and methodological responses. *European Public and Social Innovation Review* (EPSIR), 2(1), 3pp.59-77. Available from: https://doaj.org/article/fec01a42abe147b5a1b34318370e53fd.

Heidegger, M. (1962). *Being and time*. New York: Harper Row.

Heybey, B., and Murrell. (1999). The Relationship between Economic Growth and Speed of Liberalization during Transition, *Journal of Economic Policy Reform*, Vol. 3(2), pp. 121-132
Available from: http://www.tandfonline.com/doi/abs/10.1080/13841289908523400
.Hewitt, R. J., Compagnucci, A. B., Barlagne, C., and Ceglarz, A., 2019. *Social innovation in community energy in Europe: a review of the evidence. Frontier*s in Energy Research, [e-journal] https://doi.org/10.3389/fenrg.2019.00031.

Hoppe, T., and de Vries, G., 2018. *Social innovation and energy transition. Sustainability* (Switzerland), volume 11(1), art. no. 141. Available from https://doi.org/10.3390/ su11010141

Hox, J.J. and Boeije, H.R., 2005. *Data collection, primary versus secondary*.

IEA (2017), "*World Energy Outlook 2017*", IEA, Paris available from https://www.iea.org/reports/world-energy-outlook-2017 accessed on 9 November 2017
IRENA(2019), *Energy Transition* available from https://www.irena.org/energytransition. Last accessed 20 December 2019.

Investment Board Nepal: Government of Nepal(2019) , available from https://ibn.gov.np/energy#horizontalTab1

K.C.S., Khanal, S.K., Shrestha, P. and Lamsal, B., 2011. Current status of renewable energy in Nepal: Opportunities and challenges. *Renewable and Sustainable Energy Reviews*, *15*(8), pp.4107-4117.Available from DOI: 10.1016/j.rser.2011.07.022

Kumar, Ranjit. *Research Methodology*, 2010. *: a Step-by -Step Guide for Beginners*. Sage Available from https://books.google.dk/

Labanca, N & Guimarães Pereira, Â (2018) *Energy sustainability in the transition to renewables framings from complex systems and social practice theories : policy and research indications from expert discussions.* Available from:

https://e3p.jrc.ec.europa.eu/events/exploratory-workshop-energy-sustainability-transition-renewables-framings-social-practices accessed on 10 December 2019

Li, Francis & Trutnevyte, Evelina & Strachan, Neil. (2015). A review of socio-technical energy transition (STET) models. *Technological Forecasting and Social Change.*Volume100. Pp.290–305.
Available from 10.1016/j.techfore.2015.07.017

Loorbach, D., Wittmayer, J.M., Shiroyama, H., Fujino, J. and Mizuguchi, S., 2016. *Governance of urban sustainability transitions*. Springer Berlin Heidelberg.

Mahat.I(2004),Implementation of alternative energy technologies in Nepal: towards the achievement of sustainable livelihoods*, Energy for Sustainable Development,*Volume 8, Issue 2,2004,Pages 9-16,available from https://doi.org/10.1016/S0973-0826(08)60455-X.

Moulaert, F. & Ailenei, O. (2005) 'Social Economy, Third Sector and Solidarity Relations: A Conceptual Synthesis from History to Present', *Urban Studies*, 42(11):2037-2053 available from https://doi.org/10.1080/00420980500279794

Mulgan, G.; Tucker, S.; Ali, R.; Sanders, B. *Social Innovation: What It Is, Why It Matters and How It Can Be Accelerated*; Skoll Centre for Social Entrepreneurship, The Young Foundation: London, UK, 2007.

NEA (2010). Annual Report 2009-2010, *Nepal Electricity Authority,* Kathmandu, Nepal.

NEA (2019). Annual report 2018/2019,*Nepal Electricity Authority,* Kathmandu, Nepal.

Nepal, R. and Jamasb, T. (2011). Reforming the Power Sector in Transition: Do Institutions Matter? *Cambridge Working Papers in Economics 1124*, University of Cambridge, UK.

Nepal, R, and T Jamasb(2011). "Reforming Small Power Systems under Political Volatility: The Case of Nepal." *IDEAS Working Paper Series from RePEc*,

Nepal, Rabindra, and Jamasb, Tooraj. “Caught Between Theory and Practice: Government, Market, and Regulatory Failure in Electricity Sector Reforms.” *Economic Analysis and Policy* volume 46.C (2015): 16–24.

North, D.C. (1991). *Institutions, Journal of Economic Perspectives,* Vol. 5(1), pp. 97-112

NPC(2013),Nepal: *Rapid Assessment and Gap Analysis*,Nepal planning Commission
Available from
https://www.npc.gov.np/images/category/SE4ALL_RA_GA_Report_As_published.pdf

Osunmuyiwa, Olufolahan, et al(2018). “Applying the Multi-Level Perspective on Socio-Technical Transitions to the Rentier States: the Case of Renewable Energy Transitions in Nigeria.” *Journal of Environmental Policy & Planning*, vol. 20, no. 2, pp. 143–156., available from doi:10.1080/1523908X.2017.1343134.

Paterson, M., & Higgs, J. (2005). Using Hermeneutics as a Qualitative Research Approach in Professional Practice. *The Qualitative Report*, 10(2), 339-357. Retrieved from http://nsuworks.nova.edu/tqr/vol10/iss2/9

Pokharel, K. (2015, November 26). The Two-Month Blockade of Nepal Explained. Wall Street Journal available from :
https://blogs.wsj.com/indiarealtime/2015/11/26/the-two-month-blockade-of-nepal-explained/
Accessed on 9 November 2019

Poudyal, Ramhari et al. (2017) ‘Understanding energy crisis in nepal: Assessment of the country’s energy demand and supply in 2016’, i *International Electrical Engineering Congress (iEECON)*. . March 2017 IEEE. pp. 1–4. Available from DOI: 10.1109/IEECON.2017.8075797

Price, James H. and Judy Murnan. “Research Limitations and the Necessity of Reporting Them.” *American Journal of Health Education* 35 (2004): 66-67. Available from https://libguides.usc.edu/writingguide/limitations accessed on 20 December 2019

Saunders, Mark, et al. *Research Methods for Business Students*. Prentice Hall, 2009. Available from https://books.google.dk/books

Seetharaman, Krishna Moorthy, Nitin Patwa, Saravanan, Yash Gupta(2019). Breaking barriers in deployment of renewable Energy. *Heliyon 5* available from e01166. doi: 10.1016/j.heliyon.2019. E01166

Smith. E, 2008 "*Using Secondary Data in Educational and Social Research*" New York, McGraw-Hill Education.

Souvik Sen, Sourav Ganguly(2017), Opportunities, barriers and issues with renewable energy development – A discussion, *Renewable and Sustainable Energy Reviews,* Volume 69, 2017, Pages 1170-1181 available from https://doi.org/10.1016/j.rser.2016.09.137.

Sovacool, Benjamin K et al. (2011) "Halting Hydro: A Review of the Socio-Technical Barriers to Hydroelectric Power Plants in Nepal." *Energy* 36.5: 3468–3476 available from DOI: 0.1016/j.energy.2011.03.051

The Asia Foundation (2014),A Political Economy Analysis of Electricity Tariff Restructuring in NepalThe Asia Foundation Occasional Paper , Available from https://asiafoundation.org/publication/a-political-economy-analysis-of-electricity-tariff-restructuring-in-nepal/

Timma, Lelde et al. (2017) 'Novel tools to study socio-technical transitions in energy systems', in Energy Procedia. September 2017 *Elsevier* Ltd. pp. 418–422. Available from https://doi.org/10.1016/j.egypro.2017.09.048

UNDP(2007) *Energy Poverty In Nepal Challenges the way Forward,* United Nation Development Program

Verbong, Geert & Geels, Frank (2007) The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). *Energy Policy*. Volume 35 (2), 1025–1037. Available from DOI: 10.1016/j.enpol.2006.02.010

Voorberg, W.H.; Bekkers, V.J.; Tummers, L.G(2015). *A systematic review of co-creation and co-production:Embarking on the social innovation journey.* Public Manag. Rev., Volume 17,

1333–1357 availlable from http://www.tandfonline.com/doi/abs/10.1080/14719037.2014.930505. Accessed on 9 December 2019

WECS(2017), *Energy Demand Forecast report(2015-2040)*, Water and Energy Commission Secretariat, Kathmandu, Nepal

Weinsheimer, J. C. (1985). *Gadamer's hermeneutics: A reading of truth and method*. New Haven, CT: Yale University Press

Williams J.H and Ghanadan, R. (2006). Electricity Reform in Developing and Transition Countries: A Reappraisal, *Energy*, Vol. 31(6-7), pp. 815-844.