The Political Economy of Energy Transition in Mexico

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Abstract

Renewable energy as radical innovation requires not only technological substitutes but also a fundamental transformation at the system level. This means changing social elements such as policies, market rules, regulations for users and producers, and their behavior. Thus, in studying the political economy of energy transition in Mexico, this research adopts a conceptual framework that encompasses the three perspectives (techno-economic, socio-technical and political) through a multi-level perspective approach (MLP). Methodologically, the research proposes a collective case study: the wind energy region *Isthmus of Tehuantepec* in the south of Mexico and the photovoltaic power station named *Villanueva* in the north, represent the four parts of the sociotechnical electricity system from generation and transmission to distribution and retail. Structural barriers and lock-in within the system can slow down the uptake of renewable energy. At the same time, if system changes are too radical, they can encounter resistance from incumbents, leading to the failure or even slower diffusion of technology. This can be seen in Mexico where energy development and certain policies generate inconsistent responses, from economic, to social, to political. The research findings illustrate how alignment between the expectations of actors at each level (niche, regime, landscape) shape the transition. Strong alignment between these levels will provide momentum at the system level.

Keywords; *evolution of systems, climate change, energy transitions, socio-technical system, system innovation*

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Finally, I would like to dedicate this work to all the Mexican girls out there, for them to never give up, no matter how hard the situation seems to be; never stop dreaming.

Abbreviations

COCEI	Coalition of Workers, Peasants and Students of the Isthmus
CENANCE	National Energy Control Centre
CFE	Federal Commission of Electricity
BEPA	Bureau of European Policy Advisers
DOF	Official Journal of the Federation
EIA	The Environmental Impact Assessment
FAO	Food and Agriculture Organisation of the United Nations
GHG	Greenhouse Gas
INEGI	National Institute of Geography and Statistics
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IWGA	International Work Group for Indigenous Affairs
LGEEPA	General Law of Ecological Balance and Environmental Protection
MW	Mega Watts
MIA	The Environmental Impact Statement
MLP	Multilevel Perspective
MORENA	National Regeneration Movement
OECD	Organisation for Economic Co-operation and Development
PRI	Institutional Revolutionary Party
PAN	National Action Party
PRODESEN	National Electricity System Development Program
RET	Renewable Energy Technology
REN	Renewable Energy Policy Network
R&D	Research and Development
SENER	Mexican Ministry of Energy
SEMARNAT	Ministry of Environment and Natural Resources
SEDESOL	Ministry of Social Development

We need to think in systems, we need to address systems, it is systems that most urgently need to change. After 50 years of concern and policy making around climate change it is systems that are not changing.

(Johan Schot, 2018)

Introduction

1.1 Background and Context of the Research

A major challenge for all nations concerning their energy systems is reducing greenhouse gas emissions whilst securing energy resources and boosting economic growth. In the past centuries, growth was pursued without concerns on environmental consequences; countries independently followed their interests and did not understand the pollution effects as a collective action problem presented on a global scale. It is now commonplace to hear about the phenomenon of global interdependence or globalization having its roots in the international political economy literature (Cooper 1972; Keohane and Nye 1977). A key issue in considering the implications of interdependence revolves around the question of how to achieve coordination and understanding among states. The process of global integration forces significant adjustments in collaboration matters across countries, that is the case of climate change and the current reality of environmental degradation. International efforts, such as the Kyoto Protocol and the Paris Agreement, emerged with the aim to reduce greenhouse gas emissions. The dominant discourse on climate change has led to difficulties in implementing green economy approaches in national policies around the world. In some developing and emerging countries, this leads to trade-offs between the political duty to promote a lower emissions economic model, and the high costs from energy imports, or energy policies that can result in strong political opposition on social welfare.

Countries agreed to reduce greenhouse gas emissions, but the amount of carbon dioxide, methane and nitrogen oxides in the atmosphere keeps rising, heating the Earth at an alarming rate. If one acknowledges that the energy supply sector is the single most significant contributor to greenhouse gas (GHG) emissions impacting the earth's atmosphere (IPCC,2014, p.7), a long-term energy transition will be environmentally beneficial in terms of lowering emissions. For this research, energy transition refers to the global energy sector's shift from fossil-based systems of energy production, consumption and storage; including oil, natural gas and coal, to renewable energy sources; wind, solar, as well as green hydrogen. Energy transition is only possible if it is done in a fair and inclusive way.

Worldwide, the development of renewable energy such as wind and solar has had strong public support, despite its promising technology it can also bring economic and environmental challenges; noise pollution, endangerment of wildlife species, significant capital investments, monopolistic practices, among others. The negative environmental, cultural and political impacts have challenged the adoption of renewable energy, despite its promising technology. This research provides detailed account of the dynamics of energy infrastructure change in Mexico's electricity sector. Several dimensions of the Mexican energy transition are ºhighlighted by the influence and drivers of energy system. All these factors may influence the future of energy transition.

For almost thirty years, social sectors in Latin America have demonstrated resistance to renewable energy technologies through protests and disputes. Particularly in Mexico, where these projects have caused significant social opposition and conflicts in indigenous communities since the early 90's. The epistemics of social opposition in Mexico proposes downstream policy fixes by involving communities in the decision making and benefits of projects. For instance, the literature claims the violation of human and community rights by private energy investors is often associated with the country's renewable energy developments (Castillo-Jara, 2011). Alongside other factors, these can include insufficient consultation and involvement with the local community when developing a project. Until January 2021, out of the 25 wind power plants currently in operation in the southern part of Mexico[1], only one renewable development conducted a Free, Prior and Informed Consent (FPIC) procedure where indigenous communities could express their views concerning wind energy. Moving towards an increase demand for strategic resources such as lithium and green hydrogen, lessons learned from the past set the context for the country's political agenda on energy transition.

1.2 Problem ad Significance

There are many possible pathways energy transitions can take in order to adapt to rising global pressures. Whichever pathway the transition follows, it is inevitable that it will involve major changes not only to technology and infrastructure but also in society, creating a sociotechnical transition[2]. Since early 2000, there have been several ongoing initiatives in Mexico to increase the use of renewable energy technologies and to promote investment. The first wind farm in the country began functioning in 1994 at *La Venta,* an *ejido* located at Juchitán de Zaragoza in the state of Oaxaca. Outcomes generated by these seven windmills were highly applauded by experts around the world. Over the past two decades, neoliberal strategies involving the restructuring of electricity and the regulation of transmission and distribution network had resulted in improved efficiency in terms of energy production. Electricity market liberalization is essential to lower costs and prices for renewable energy sources. This trend attracted a fair amount of attention from international investors around the world and by 2017, Mexico had received the second largest amount of renewable energy investment in Latin America after Brazil (Bloomberg New Energy Finance, 2018). Domestically, former President Enrique Peña Nieto introduced legislation to promote electricity market liberalization. As a result, different instruments were introduced together with the Mexican Emissions Trading System (ETS) and

[1] The southern part of the country makes reference to the *Isthmus of Tehuantepec*, where the majority of wind energy resources are concentrated.
[2] A sociotechnical transition refers to the evolution and development of a sociotechnical system.

energy auctions for private energy producers. With the change of government in 2018, the national energy strategy was shifted to energy security. On January 2nd, 2020 the national energy system shift was published at the federation's official journal (DOF), the main strategic goal being to decrease import sources and secure domestic energy supply. The official document claimed that energy independence will improve the country's sovereignty (SENER, 2020). The following year, in February 2021, President Andrés Manuel Lopez Obrador introduced reforms on the Electricity Law that favors energy produced and dispatched by the Federal Electricity Commission (CFE)[3]. This initiative sought to strengthen the Federal Electricity Commission by improving on articles 4, 25, 27 and 28 of the political constitution. However, the second quarter of 2022 the electricity reform was discarded due to the lack of 332 votes required to be approved. The Wholesale Electricity Market (MEM) obtained its victory and with it the possibility to continue operating normally. Energy auctions in which private investors compete for projects and the relevant criteria for obtaining Clean Energy Certificates (CEL) from clean sources. After the latest reform in February 2021, article 16 exempted producers from obtaining the certificates and since 2022 both have been abolished. In terms of political strategy, contradictions can be seen between the former and current governments. While the focus of the previous government was the global environmental target of reducing GHG emissions and favoring market liberalization, the current government has prioritized energy security. Overall, this study addresses the two research questions of "How do global forces (landscape-level) influence the speed and directionality of the energy transition in Mexico?" and "How does social resistance to energy systems emerge?".

[3] The reform erase from article 4 the principle of "economic dispatch" in which favoured the most efficient or less expensive source of energy as they could distribute their generated energy to the national grid first. This principle often favoured energy sources coming from private investors such as renewables.

1.3 Objectives

The thesis analyses the changes in national policy direction, as it relates to the emergence of social resistance to renewables as well as global and macroeconomic factors influencing the direction of the transition. The rapid and large-scale deployment of renewable investment in Mexico was not favorable that represented a major social challenge, rising questions about how benefits are shared and how policymaking is conducted. These renewable developments are often located in peripheral areas where indigenous people live in close symbiosis with their surrounding environment. Energy developments are having a significant impact and are encountering a range of reactions in communities from economic to social to political. Indigenous communities in Mexico have opposed renewable energy developments, viewing them as embodying the commercialization of biodiversity, leading to the degradation of the ecosystem (Mikkelsen et al., 2015). For example, the state of Oaxaca, which produces 97% of national wind power (Juarez-Hernandez and Leon, 2014), has a population of almost four million people, of which 65.7% speak only an indigenous language (INEGI, 2015). Of the 25 onshore wind farms currently found in this area, 78% are for the private use of mainly Spanish and French energy companies and only 22% distribute electricity to the national grid for public consumption. None of the supply the local communities directly or is community owned (Pozas et al., 2015, p.105). La Venta I, also located in this area, has been surrounded by controversy due to its impact on endangered migratory birds who collide with the windmills (Avila-Calero, 2017). In addition, the first photovoltaic power station, *Villanueva,* to start operations after the country's last energy reform in 2018, was accompanied by protests and strikes. Workers complained about failure to pay their salaries and poor living standards (Iturriaga, 2018).

These examples illustrate how research that focuses on the uneven distribution of gains and losses among social groups and regions at a local level, is vital for understanding the systemic difficulties associated with energy transition. When transformation is implemented incompletely or inappropriately, problems will emerge further down the line that can incur huge costs both in time and money (Joskow, 2008). In other words, when implementing radical innovations such as renewable energy developments nationally, attention must be paid to the major changes that are required at the system level[4] and the impact these changes will have for multiple social aspects such as policies, regulations, behavior of users and producers, policies and market rules that form the basis of an industrialized country.

Given this context, this study sets out to demonstrate through a qualitative lens the complex interactions between actors and exogenous macro trends as the impact transitions to low carbon energy systems. Implemented policies and political actions are considered at a national level that have influenced the power sector in Mexico. Additionally, pathways of local resistance that can potentially influence changes in the system are identified. The unit of analysis is the country case study (Mexico), with a focus on two renewable energy including location, communities, institutions and organizations. Subsystem components of the energy system interact with and are embedded in government, social, technological and global pressures. Therefore, this study introduces a collective[5] approach that will help to understand how energy transition is moving in terms of directionality and speed. To address these objectives, the research sought to answer the following two research questions:

- How does social resistance to energy system change emerge; what are its main influences/pressures in the case of Mexico?

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[4] The conceptualisation of a "system", for the present research refers to elements that are fine-tuned to each other such as the configuration of technologies, services, infrastructure, regulations and actors (for example, producers, suppliers, policymakers and users) that fulfils a societal function such as energy provision (Schot et al. 2016, p. 2).

[5] The study's cases can also be considered instrumental, the purpose is to create understanding beyond the cases themselves. A case study can be part of a wider phenomenon that is being studied (Stake, 1995).

- How do global forces (landscape-level) influence the speed and directionality of the transition in Mexico?

1.4 Methods

The overall research is positioned at the intersection of Political Economy, Evolution of Systems and Sustainability Transitions. Data was collected mainly through historical cases means that secondary data was relied on heavily. Sociotechnical transition studies commonly utilize historical case studies in combination with interviews. For instance, Sovacool et al. (2012) used 149 in-depth interviews at 89 institutions to examine the growth of the Solar PV market and social acceptance between 1991 to 2007 in Germany, the United States and Denmark.

For this research, primary data was collected using semi-structured interviews conducted between March 2020 and August 2020. It is important to mention that methodology and research approach were affected by the global COVID-19 crisis. Although, the pandemic posed serious challenge to the research, particularly to the fieldwork and primary data collection, I was able to adapt to these challenges and conducted a total of 20 semi-structured interviews via telephone, email and Zoom calls. Additionally, the interviews were useful for mapping, analysis and verifying the reliability of the secondary data that was collected throughout the three years of research.

The following table shows the number and order to interviews in relation to each case or level; nine in relation to the *La Venta* case study and ten in relation to *Villanueva.* Participants were divided by the three complex levels proposed by the multi-level perspective (MLP) for exploring sociotechnical transitions.

Table 1. The Three Complex Levels by Case Study. *Source: Author's own.*

Level	Type (local authority, energy company, regional authority, trade association)	Total
Cases Niche (local-level)	*Case 1 La Venta*	4
	Case 2 Villanueva	5
Regime (meso-level)	*Case 1 La Venta*	6
Landscape (macro-level)	*Case 2 Villanueva*	4

An inductive approach was used as is common in the research area (Smith et al., 2010)[6]. An initial literature review was conducted on system innovation and approaches for understanding national transitions, in order to contextualize the study in the literature. The case study approach was used in combination with semi-structured interviews.

1.5 Scope and Limitations

This research addresses the gap in the transitions debate by using a systemic perspective approach to generate a better understanding of transition in all its complexity, without breaking it down into isolated components. The approach also allows emerging properties specific to a level (micro-level, meso-level and macro-level) to be identified. Comprehensively, it favours the communication and generalization of the larger phenomena being studied, which is the transition of sociotechnical regime to renewable energy. The original contribution on the field is threefold. First, the present research does not focus on the emergence of radical innovation,

[6] An inductive approach is also called a "bottom-up" approach, works from specific observations where patterns are identified to build generalization.

but rather, on the synergies of the transition which involve social resistance, innovation substitution and policy for the co-evolution of existing regimes. Second, it constructs a cause-effect theory for understanding energy transitions in developing countries from a political economy perspective. This is done by exploring three groups of variables, techno-economic, socio-technical and political, to better understand niche dynamics and relations between various levels of decision making. Finally, the entire doctoral thesis aims to elucidate the analytical and methodological challenge that energy transition studies face in Mexico and in developing economies. In this sense, it responds to those who have pointed out that the "Political economy of energy transitions is a vastly understudied area" (Goldthau & Sovacool, 2012, p. 238).

Due to the length of this research, it will analyse two cases influencing energy transitions, recognising that there might be many more factors involved in the process. It is expected that the conclusion from this project can inspire future research to broaden the knowledge on energy innovations. Further and more narrow research can investigate the link between certain environmental or different social factors impacting innovations and policy. The study seeks to raise awareness amongst the academic and social development communities through its findings. It is also important that civil society is informed about the benefits of getting involved in the energy transition, this is done through my monthly column on energy transition printed in Mexico City by international Magazine Expansion.

1.6 Structure of the dissertation

The thesis consists of seven chapter beginning with this introductory section. Each chapter engages with a different moment of the research. Chapter 2 provides an overview of the first stage of the research design, beginning with a systematic literature review (SLR) and outlining the structure and software that were used to help manage data. It then outlines the theories and analytical framework utilised and describes the methods and strategies used to collect data. It also elaborates on the modifications made to the initial research design as a result of the global COVID-19 health crisis. It argues and justifies each case study method used. The chapter concludes with a brief discussion of the study's limitation and ethical considerations.

Chapter 3 explores the existing energy system in Mexico through the lens of the metatheoretical framework. It summarizes current literature on the three perspectives through which national energy transitions have been analysed (socio-technical, techno-economic and political). To understand the origins and theories that underpin this research field, an overview of Science and Technology Studies (STS) will provide the theoretical background. The chapter outlines the two major stands relevant to the study sociotechnical transitions, the multilevel perspective and innovation (MLP) and the techno-economic paradigm (TEP) will be combined to create a new energy transition framework.

Chapter 4 engages with the mobilisation, power-resistance relationships, and politics in Isthmus of Tehuantepec. It seeks to explore how, why, and by whom the wind energy is contested in Isthmus of Tehuantepec. Transition dynamics such as speed and directionality are the basis for bringing together the previous chapter in terms of how they relate to the drivers and barriers of and to transition. This chapter addresses the first of the study's research question. A combined approach of the concepts of sociotechnical transitions and innovation dynamics is proposed as a highly useful resource to develop energy transitions.

Chapter 5 addresses the study's second question, providing the broader context of the transition. It includes a description of key aspects of the photovoltaic plant site in the north of the country from a micro-level point of view. Relevant policy information and a selection of quotes from interviews are discussed. Additionally, the chapter gives an overview of the most relevant

Mexican policies in the electricity sector of the past twenty years. It concludes with a focus on transition dynamics.

Chapter 6 discusses the findings and theoretical implications and study limitations are summarised as concluding remarks. It begins with an analysis of the case studies in relation to the analytical framework. Finally, the future of the transition to renewable energy is examined through the three perspectives on national transitions.

Chapter 2. Methodology

2.1 Systematic Literature Review

Many concerns and interpretations have been used to identify energy transitions. The first step of this research was therefore to conceptualise the notion of energy transition. Through an initial trawl of the literature, the following working definition was found: "the agglomeration of social changes and trends that encompass techno-economic and environmental features related to the change in structure of an energy system." In contrast to the other gradual changes, transition to sustainability takes into consideration new macro phenomena while bearing in mind the local-based issues that emerge. The two research questions were designed to take into account the local-level and macro-level aspects of phenomenon of energy transition.

Once the concepts were defined and the two research questions articulated, a systematic literature review (SLR) was conducted in three stages[7]. The aim was to evaluate and deepen understanding about energy transitions from a social-scientific point of view. To do so, in the first stage a search of the literature was carried out through SCOPUS between November and

[7] This form of literature review consists of an overview of existing evidence pertinent to a clearly formulated research question. It is increasingly used in the social sciences.

December 2018. SCOPUS is an abstract and citation data base launched in 2004. It covers the fields of science, technology, medicine, social sciences, arts and humanities. One of the reasons that SCOPUS was chosen among other databases is because it has various formats of quality and high ranked literature such as books, book series, peer reviewed journals, trade journals, conference papers and other formats. Also, it has a far reach and a multidisciplinary index database that is integrated into ScienceDirect, Engineering Village and other Elsevier sources. The entry query was “energy system(s)” combined with search terms such as “innovation(s)”, “sustainability” and “transition(s)”.

The following set of inclusion and exclusion criteria was applied for the search of relevant literature: (1) the outputs should be limited to social science; (2) the studies should be from high ranking peer reviewed journals; (3) they should be in English; (4) publications should be between 2008 and 2018. Papers based on geographical coverage were not excluded even though the thesis analysis is based in Mexico. Additionally, at this time an active alert was set monthly for new literature to come, covering the full research time frame. Once key literature started emerging, the “snowball” search method was a useful way of finding literature by taking key documents as a starting point. As a result, for the first stage, the following three main topic area emerged as relevant: system innovation, sustainability transitions and energy systems.

Table 2. Systematic literature review. *Source: Author's own*

	System Innovation	Sustainability Transitions	Energy System*
Year	#Total Articles	#Total Articles	#Total Articles
2008	20	5	228
2009	29	6	247
2010	38	8	275
2011	46	30	455
2012	52	36	493
2013	85	74	518
2014	77	86	732
2015	114	122	835
2016	123	182	1159
2017	160	266	1499
2018	628	442	2056
2019	300	501	2600
2020	342	742	3033
Total	2014	2500	14130

*Energy System limited to social sciences

Key peer-reviewed English publications that host academic debates on energy transitions were identified; *Technological Forecasting and Social Change, Energy Policy, Research Policy, Global Environmental Change, Energy & Social Science and Environmental Innovation and Societal Transitions.*

Once the first stage of the systematic literature review was concluded, the findings were divided into four main areas (see Table 2). During the commencement of stage two, NVivo data analysis software was used as a tool to help prioritize reading and make connections between sources. Theoretical literature was studied to address the research approach intended for this project. The second step was to identify the main authors by study area, the field of theory, and examples of models and applications (see Table 3).

Table 3. Structure of literature review. *Source: Author's own*

Area	Topic	Purpose or applications	System focus	Field of theory	Publication
Sustainability Transitions	- Theories or frameworks on National energy transitions.	Deeper understanding of dynamics and perspectives on national energy transition.	Energy policies related to global factors, technological innovation and political actions.	Political science, international relations, evolutionary economics	(Cherp et al. 2018)
	- Approaches for understanding national transitions.	Transition literature encompass; Transition Management (TM)[8], Multilevel Perspective approach (MLP)[9] and Technological Innovation.			(Smith et al., 2010; Loorbach, 2010; Geels, 2002; Jacobsson and Johnson, 2000).
System Innovation	- Innovation Studies and theories - Science and Technology Studies (STS)	Two innovation modes STI and DUI modes of innovation. Conceptualisation of social innovations that have been implemented to support evolution of systems.	Energy technologies embedded in sociotechnical systems	Evolutionary and institutional economics	(Hess et al. 2020; Sovacool et al. 2020)

[8] Transition Management examines how transitions can be managed through strategic public decision makers and private actors with a more process-oriented approach (Rotmans et al. 2001)
[9] This research utilizes the multilevel perspective (MLP) which is one of the main approaches to understand sociotechnical transitions.

	- Sociotechnical systems	Theories on sociotechnical transition studies and system innovation.			(Geels 2002; Sovacool 2018; Sorrell 2018; Schot 2007)
Energy System	- Markets and prices	Planetary economics that encompasses (energy subsidies, gasoline taxes, etc.)	Energy flows and markets	Neoclassical and evolutionary economics	(Grubb, 2014)

2.3 Theories and Analytical Framework

The majority of publications on energy transitions use existing theories for analyzing empirical cases of transition. However, a few studies have proposed new theories of transitions (see for example: Cherp et al., 2018; Geels, 2012; and Bashmakov, 2007). To identify the most relevant literature, an initial set of articles was selected with the aim of finding a similar conceptualization of energy transitions as used by this research. As a consequence, the term "sociotechnical transition" was identified as it aligns with the study's understanding of a transition for two reasons: firstly, the systems are conceptualized as "sociotechnical" since they involve multiple, interlinked social and technical elements such as technologies, market, industries, infrastructures, policies, users, practices and societal discourses (Geels et al. 2018). "Sociotechnical Systems" change over time and evolve into new systems. This process has come to be referred to as a "sociotechnical transition". Similar to the understanding of transitions underlying this thesis, it is seen as crucial to engage with multiple social groups and activities in the context of rules and institutions. Secondly, the literature on sociotechnical transitions differs in its conceptualization of "innovation" which more conventional models tend to view as a linear process and disregard social factors[10]. According to these models, technological developments are assumed to follow their own internal logic, largely detached from society, leading to potential social changes once they are introduced into society (Geels et al. 2018).

Innovation is basically defined as the first-time application of newly acquired ideas, technological products or methods to the products and processes, providing the basis for future developments concerning technology, consumers or firms (Greenhalgh et al. 2010, p.4). Due to its importance, the term is used in business, scientific bodies and most recently, within social and environmental practices. On the one hand, innovations in technologies are producing environmental benefits which have resulted in pressures to reduce the use of products that harm the environment. On the other hand, few innovations have a large-scale social impact, and fewer still result in long-term breakthroughs that lead to the adoption of new solutions that satisfy both environmental pressures and social needs (Dawson & Daniel, 2010).

A well-defined understanding of the innovation model is crucial in moving towards a more environmental and social approach. For instance, the change from neo-classical innovation model towards an evolutionary model was fundamental to an understanding of the role of innovation in adapting to changes and comforting new challenges (Rennings, 1998). From a theoretical perspective, innovation towards sustainability has proven so far to be stimulating a long-term shift from neoclassical methods to evolutionary innovation models are limited in terms of analyzing environmental changes, because neither consider the societal context.

Table 4. Innovation Model. *Source: Author's own based on (Feldman, 1994; Saviotti, 1996; Nicholls et al., 2005; Grometta et al., 2005: 2007; Phills, 2008).*

[10] Neoclassical economics also provides a rationale for supporting new, energy efficient technologies. According to Geels et al. (2018) it offers limited insights into the process of innovation or the most efficient means of policy support.

Neoclassical Innovation Model	Evolutionary Innovation Model	Social Innovation Model
Technological newness as a driving force for innovation (Feldman, 1994).	Innovations are seen as the continuous generation of new products, processes and forms (Saviotti,1996).	Established that innovations are aimed at solving social needs (Phills 2008)
Technological Change (Feldman 1994).	The introduction of new products as adaptation to the environment (Saviotti 1996).	• Changes in social relations (e.g., governance, the involvement of deprived groups) (Grometta et al., 2005; 2007). • Empowerment dimension (Grometta et al., 2005: 2007).
It is "market-driven" and places demands on the technology of potential consumers (Feldman, 1994).	Fitness and adaption: "Darwin's survival of the fitness" represents the propensity to be successful in a new environment (Saviotti, 1996).	Social innovation can take place in any sector (Nicholls et al., 2005)

The sociotechnical approach again takes this further by focusing on innovation processes as creating new sociotechnical system through the co-construction of multiple elements (MacKenxie et al., 1999; Oudshoorn, 2003). Besides technological changes, sociotechnical transitions also involve changes in infrastructures, regulations, markets, user practices and so on. We can take example of the electric car-sharing concept *MOL LIMO* and its successful implementation in Budapest. The current system is cantered on an individual artefact – the car, which is linked and dependent upon a multi-layered social, economic, and technical entity. These layers may include the global car industry, the global oil industry and the associated infrastructure of oil networks, refineries, pipeline, fuel stations, etc.; the road infrastructure together with its rules and regulations, and associated industries; concrete and asphalt production and demand etc.; and the multiple institutions, regulations and policies associated with the production and use of the car, among many others. Once these different entities have been identified, they will have to act together and shape the mode and pattern of personal mobility. The evolution from gasoline automobile to electric, and from individual ownership to a sharing mode, will become the aim. Once the goal is set, efficient electric cars have to be developed, followed by an established online presence and physical infrastructure for car rental such as charging stations, easy payment facilities, positive political support, strong political ties, wide promotion to ensure social acceptance among users, etc. Also, at an early stage of the transportation process, it can gain momentum from economies of scale to reduce the production and distribution costs. According to Sorrell (2018), inferior technologies can come become dominant when they obtain an early advantage that allows them to benefit from mechanisms such as economies of scales to reduce costs, thereby lowering the production costs and encouraging demand. Overall, success with transitioning from internal combustion engine to electric motor vehicles relies on multiple entities and practices engaging simultaneously for the system to be constructed.

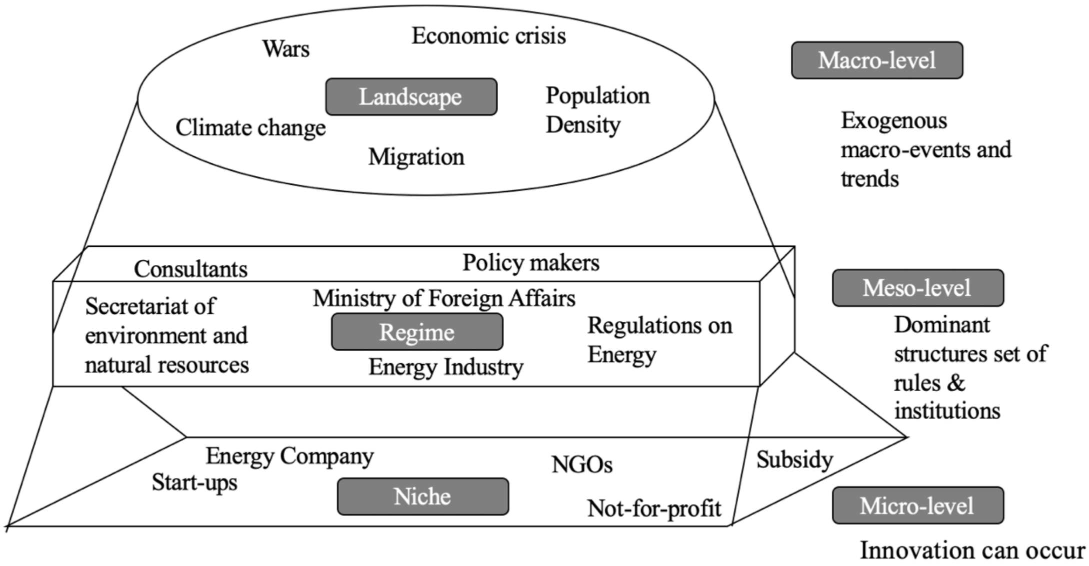
The socio-technical system approach is concerned with the interactions between various actors at different levels in the development and diffusion of innovations (Geels et al., 2018). As illustrated in Table 2, the multi-level perspective (MLP) proposes three complex levels (micro-level), regime (meso-level) and landscape (macro-level) for exploring sociotechnical transitions, with the aim of understanding the conditions and processes under transitions. To do so, MLP integrates ideas from three fields of theory; evolutionary economics, social constructivism and sociology. Radical change within MLP is understood as the result of interactions between concepts of social expectations and social practices, technology studies, path dependence and lock-ins with the three levels; niche, regime and landscape. In other words, the system structure can encounter internal difficulties and what MLP does is to make the interactions between actors, rules and norms visible for a system to be u synchrony. Radical innovation is developed in *niches* while the dominant institutions, technologies, industries or organisations which are influenced by rules, social norms, etc, are referred to as *regimes*. Finally, the *landscape* imposes pressures upon both niche and regime. These are briefly elaborated below:

Niche: a niche is a space formed by policymakers and protected from direct mainstream market pressures with the goal of developing novel technologies. These may include local organisations or incumbent actors that are well resourced (Markard, 2006). Overall, it is a space in which radical solutions are being developed; despite this, niche innovations frequently fail but, in some circumstances,, within the right context, they can gain enough momentum to improve performance, reduce their costs, achieve a larger diffusion and trigger change into another system element (Geels, 2002; Sorrell, 2018; Schot et al., 2016). It is argued that under certain conditions, the niche has the potential to "break through" and challenge the existing regime. The shift of a technology from one niche to another is challenging and involves experimentation, adjustments, reconfigurations and learnings (Geels, 2002). Compared with regimes, niche actors are fewer, their interrelations dispersed, the focal technology immature and the guiding rules in constant flux.

Regime: is a shared, stable and aligned set of rules, routines and social norms that guide the behaviour of actors on how to produce and regulate a system. It refers to dominant technology, infrastructure, industries, supply chains and organisations associated with delivering a particular societal function (Schot et al., 2016; Sorrel, 2018). These intangible elements located at the regime level are collectively termed the *sociotechnical regime* (Geels, 2002; 2004=. In terms of a sociotechnical system, the rules mentioned force the evolution along a specific trajectory of incremental innovation, One can take the centralised system of energy production as an example of these various embedded rules. For instance, the dominant fossil fuels and energy intensive practices are guided by rules that favour large-scale production at the lowest possible costs, regulations through central government and individual use of abundant available energy (Schot et al., 2016).

Landscape: The landscape is a relatively static set of factors, in other words, an external context that actors cannot easily influence. The *landscape* may influence the system through either gradual change such as demographics, macro-political developments and cultural preferences or short-term shocks such as economic recession (Sorrell, 2018). In this regard, Van Driel and Schot (2005) elaborate the concept as being constituted by three factors: rapid external shocks, such as wars or fluctuations in the price of oil; factors that do not change or that change only slowly such as climate; long-term changes, such as industrialisation in the late 19th century. We can understand is as "exogenous macro-events and trends such as wars, migration, urbanization and the totality of infrastructure that shape the dynamics between niches and regimes but are not affected by the latter in the short or mid-term" (Schot et al., 2016, p.2).

Figure 1. Three complex levels in sociotechnical systems. *Source: Author's own, adapted from Geels (2002).*



In conclusion, the three levels in sociotechnical systems form the theoretical framework for the reasoning behind the research design. At this stage, there was enough information to complete phases one and two of the SLR. The following section explores the research design for the thesis. Once the research design was defined, stage three of the SLR covering historical documents and grey literature was undertaken between November 2019 and March 2020. This section concludes by describing the ethical clearance that was required in order to commence the fieldwork.

2.4 Research Design

The research design is based on the study's research questions as well as previous research in the field of sociotechnical transition studies. Case studies have been categorised into different types by various researchers, the three main types being: collective, involving a group of cases; instrumental, used to understand something beyond the case study itself; and intrinsic, where the researcher has an interest in the specific case. Within the instrumental case approach, a case can be part of a wider phenomenon. In this way, the case study approach utilized in this research is “collective” and “instrumental”. It explores in a collective manner, strategic actors, stakeholders and components of the energy system in Mexico, with the aim of studying the wider phenomena of the transition from a sociotechnical regime to renewable, in terms of interactions and embeddedness within the government, society and technology.

This section will introduce through five reasons; Why Mexico is relevant for this research?

Understudied Area: both economically and culturally, Mexico is a major player in Latin America and on the global stage. The political economy of energy transitions is a vastly understudied area, particularly in emerging economies. According to the International Monetary Fund, Mexico is the world’s 14^{th} largest economy and is member of the G20.

Leading Role in Latin America: According to the Center for Economic and Business Research (CEBR), Mexican economy surpassed Spain and Australia at the end of 2022. Mexico reached 10,046 USD per capita or the equivalent to 1.273 trillion USD. As a young country, having a history of 202 years of independence and taking in consideration its vast economic development, Mexico is considered a role model for other countries in Latin America.

Delivered Targets: Besides, Mexico became the first developing country to deliver its intended National Contributions (INDC’s) for reduction of greenhouse gas emissions to the UNFCC.

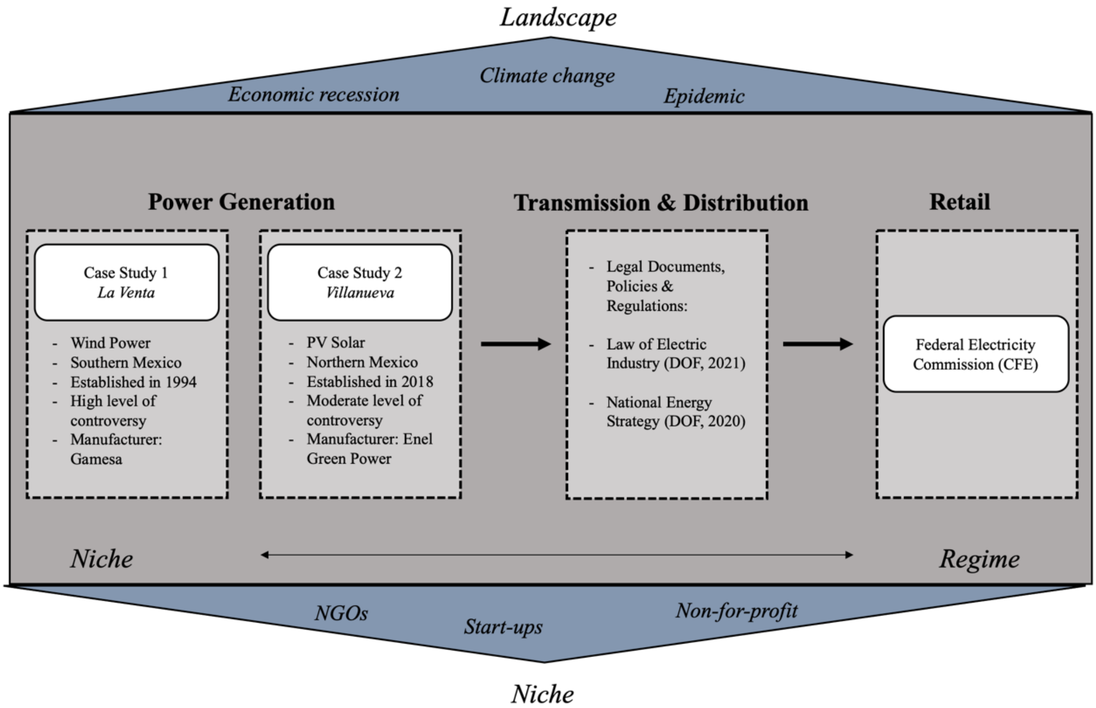
Major Investments in the Region: In 2017, Mexico received the largest amount of Renewable Energy Investment in Latin America by country (Bloomberg New Energy Finance, 2018).

Political Commitments: In the past two decades Mexico has followed up on its international commitments with a domestic agenda composed of aggressive promotion of renewable energy, modernisation of electricity infrastructure and laws to promote a lower emission economic model.

As mentioned in the introduction, this dissertation asks the following two questions: How does social resistance emerge (what are the main influences/pressures) related to system change? and how do global forces (landscape-level) influence the speed and directionality of the transition? In order to answer these questions, two major renewable energy installations were studied: La Venta and Villanueva. As previously mentioned, a range of methods have been used to examine sociotechnical transitions. Sociotechnical transition research tends to be framed from a systems perspective (Markad et al., 2012). This study also uses a systemic approach as it focuses on the whole sociotechnical electricity system in terms of generation, transmission, distribution and consumption, through a case study approach in combination with semi-structured interviews. The approach was chosen due to its ability to offer explanatory data.

The case study approach and the interview method are commonly utilized when examining sociotechnical transition (Fudge et al., 2015). A case study is the unit of analysis and it is most commonly considered to be a location, community or organisation (Bryman, 2012). Often, a single country case study is used in empirical research on sociotechnical transitions with the application of the multi-level perspective (MLP) (Geels, 2011). There are a number of advantages for the case study approach over other research designs. The case study method allows for a holistic, in-depth investigation of the nature and complexity of a particular phenomenon (Stake, 1995). Figure 2. organizes both case studies at the regime and niche levels; each of the cases represents a different manufacturer, is located geographically in different parts of Mexico (North and South) and is at a different stage of development from fully operational to recently completed after the energy reform. The following figure illustrates the research design of the doctoral thesis.

Figure 2. Qualitative case study approach for the present research. *Source: Author*



Criteria were set for the research design to begin with. Firstly, it was taken into consideration that historical case studies are favoured in sociotechnical transitions, as they are generally completed events that have the advantage of being able to be examined in their entirety (Geels & Turnheim, 2012). Research on past technological transitions is useful because they have been found to follow similar patterns with different features, depending on the context, actors and technologies involved (Bennett, 2012). La Venta was chosen as a historical case study, as it is the first wind power plant to be built in Mexico. For this reason, there is a lot more information available in the form of scientific publications. However, it is important that transition research also focuses on current projects to evaluate the learning experience and current general context. In order to meet the criteria, the most recent and large photovoltaic (PV) solar park was included. Villanueva was the first power plant to start operations in 2018 after the country's energy reform was introduced. These two cases cover both controversial and relatively non-controversial developments, in order to generate a broader understanding of where and how the learning is moving in terms of development.

Two approaches can be used to analyse case studies: a hypothesis led inquiry to collect data or question generation to guide data collection. As previously explained, the research and selection of case studies were guided by the two research questions formulated after stage one and two of the SLR. The political economy analysis provides a "thick description" in which key features are characterised to provide depth of understanding on sociotechnical transitions in Mexico. In this sense, the research needed enough data (from secondary, primary and grey sources, etc.) to share the experience and interpretation of each case. The unit of analysis is the country – Mexico, and the collective cases are subsystem components which include two renewable developments: a photovoltaic solar park and a wind power development.

By using multiple cases within Mexico, there is an increase in the explanatory power and thus in the generalisability of the collected data. The study focus is on the electricity system rather than other forms of energy because of the targets and policies, and the interaction with society. According to Geels (2014), electricity production is often seen as the sector where the most progress has been made so far, and where there is a wider scope for further carbon reduction. Moreover, it examines the influence and main characteristics of innovation on the environment and its effects on society; in other words, the present research aims to understand innovation in its societal context.

2.5 Qualitative Case Study Approach

Semi-structured interviews with participants were conducted between March 2020 and August 2020. The aim was for participants to talk about their personal opinion and not as representatives of the company, university or organisation that they belong to or represent. The interview format was the same for all the participants (see Appendix B) and was shared prior to their confirmation and participation in the form of a questionnaire. Participants were categorised by case study, organisation and level (niche, regime and landscape). Each participant was categorised according to their position at the university, company, organisation or governmental institution. None of them was personally known or related. Initially, a total of 63 participants were contacted to ask for their anonymous involvement in the research; of those, 20 interviews were completed. The following table shows the order of interviews and participants by organisation and structure within the electricity system.

Table 5. Semi-structured interviews by case study. Source: *Author's own*

Level		Type	Total
Niche	Case 1	Community organisations	3
		Energy companies	2
	Case 2	Regional Authority	3
		Local University	4
Regime	Federal Electricity Commission (CFE), Secretariat of Energy (SENER), National	National Authority	2

	Institute of Electricity and Renewable Energy (INEEL), etc.	Energy Company	2
		Not-for-profit	1
Landscape	International authorities on environmental concerns and climate change, policy makers, EU authorities.	International Expert	1
		EU authority	1
		Not-for-profit	1

As a result of the coronavirus pandemic, the research design was modified as follows;

- Interviews could not take place in the geographical location of each case study
- The scoping trip planned to the two locations between June and July 2020 with the aim of reconnaissance and to collect preliminary information, was cancelled.
- Permission was not given by the participants to make a recording via phone call or zoom interviews. Twenty interviews were gathered instead of twenty-two.
- Fieldwork was cancelled. Instead, an invitation by the Ministry of Sustainable Development was extended to provide recorded seminars for schools on sustainable development.
- Additionally, participation in a political national debate organised by the Institute of Youth, where findings and views generated by the study on energy transitions were discussed.

2.6 Study Limitations

Limitations can be divided into one that is determined by the field and one that arose due to the research methods chosen. One of the challenges of transition studies is that a transition tends to occur over a large time frame such as 25 years or more (Markad et al., 2012). For current energy systems, many lessons can be learnt from history. for example, the evolution from a traditional pre-industrial system relying on biomass to the use of coal (steam power) in an industrialised system. Based on historical research, completed transitions are more exact due to their nature but are weak in terms of being able to inform current events. In this sense, one of the study's limitations is that it investigated a sociotechnical mid-transition. Historical energy transitions are completed over many decades; clearly, this does not apply to the present energy transition, given that it is ongoing and taking place within different technological and social conditions.

A qualitative study is limited in size and scope. This study for example can be seen as involving too few participants to carry out a thorough cross-checking of the secondary data collected for the analysis. To address this limitation, key informants were selected in relation to their importance to the organisation and positions. Follow- up interviews were conducted within a six-month time-frame for further clarification and discussion with the participants. What was lost in keeping the study to a manageable size was gained in terms of quality of information available for analysis. Addressing the potential limitations of scope, the two case studies were judiciously chosen to represent two innovation types in all their multi-layered complexity. In this sense, the study makes a valuable contribution to the literature on energy transitions and system innovation. This research is relevant in terms of providing a political economic analysis of the energy system structure in Mexico.

2.7 Ethical Considerations

To ensure that the research was ethical in all respects and throughout the research, the aim of the study was made clear to participants from the beginning. There was no reward for participating and it was made clear that the study is an academic research and not connected to any government or organisation. Consent was sought via email in that participants were asked whether they were interested in being interviewed before being approached individually. Each participant gave their written consent via email about their understanding of the purpose and scope of the study. It was explained to each participant that their participation was voluntary and that therefore, they could withdraw at any point. Finally, it was ensured that all the participants knew that their participation would be anonymous. In this way, participant's actual names are not included in the analysis or in any section of the research. A request for ethical approval from one of my supervisors was requested before undertaking the interviews.

Chapter 3 Existing Energy System

This chapter offers an analytical framework to understand the existing energy system in Mexico through the lens of political, techno-economic and socio-technical perspectives, to understand why, how and by whom the Mexican energy sector has been operated. The ways in which Mexican society uses energy has changed over time, is changing at present and will continue to change. This evolution, among other factors, is shaped by economic development, technological innovation and policies (Cherp et al., 2018). At the same time, the energy trilemma over affordability, environmental sustainability and security has regained momentum among governments and academia; an exponential increase in peer-reviewed articles on energy sustainability can be seen between 2008 and 2020 (see Table 2.) These include discussions over interrelated dilemmas intricately linked to economics, population growth, and supply and demand. The central focus is “energy security”, which is a term referring to the association between national security and the availability of natural resources for energy consumption. Access to cheap energy is seen as the main concern essential to the functioning of modern economies (IEA, 2018). Within this framework, industries such as coal and petroleum have positioned themselves as affordable and secure energy sources. Nuclear power, together with natural gas, have also been repositioned as “secure” low carbon energy sources, or in other words, a “bridge fuel” towards a low-carbon future, offering emissions reduction and secure energy for a nation at a lower cost. Yet such concerns can only be meaningful if they are based on a systematic understanding of national energy transitions. In other words, a major challenge in explaining energy transitions is the disciplinary diversity of scholarly approaches. Transition literature in recent years concurs that a single theory of transition may not be feasible due to its complexities; instead, energy transitions should be analysed using several theories (Grubb, 2014; Geels and Turnheim, 2012; Geels et al., 2016)

This chapter thus utilises a meta-theoretical framework first introduced by Cherp et al. (2018). The objective of this section is to advance understanding of energy transition based on different stages and strategies existing in the Mexican energy system. The first subsection explores the three perspectives on national transitions to provide an introduction to the reader. It is followed by the political specificities of the energy sector in relation to society. It emphasises the centralized approach of policymaking and explores the path-dependency and system lock-in in the transition dynamics. To understand the sociotechnical theoretical perspective, an overview of Science and Technology Studies (STS) will be connected to a broader understanding of national transitions. Finally, the techno-economic perspective enables the reader to understand energy transition from a centralized perspective by interrogating the effects of its dynamics upon society, mobilisation and livelihoods. This chapter, therefore, comprises three sections, each one describing a stage of the electricity energy system.

3.1 An Overview of the Three Perspectives on National Transitions.

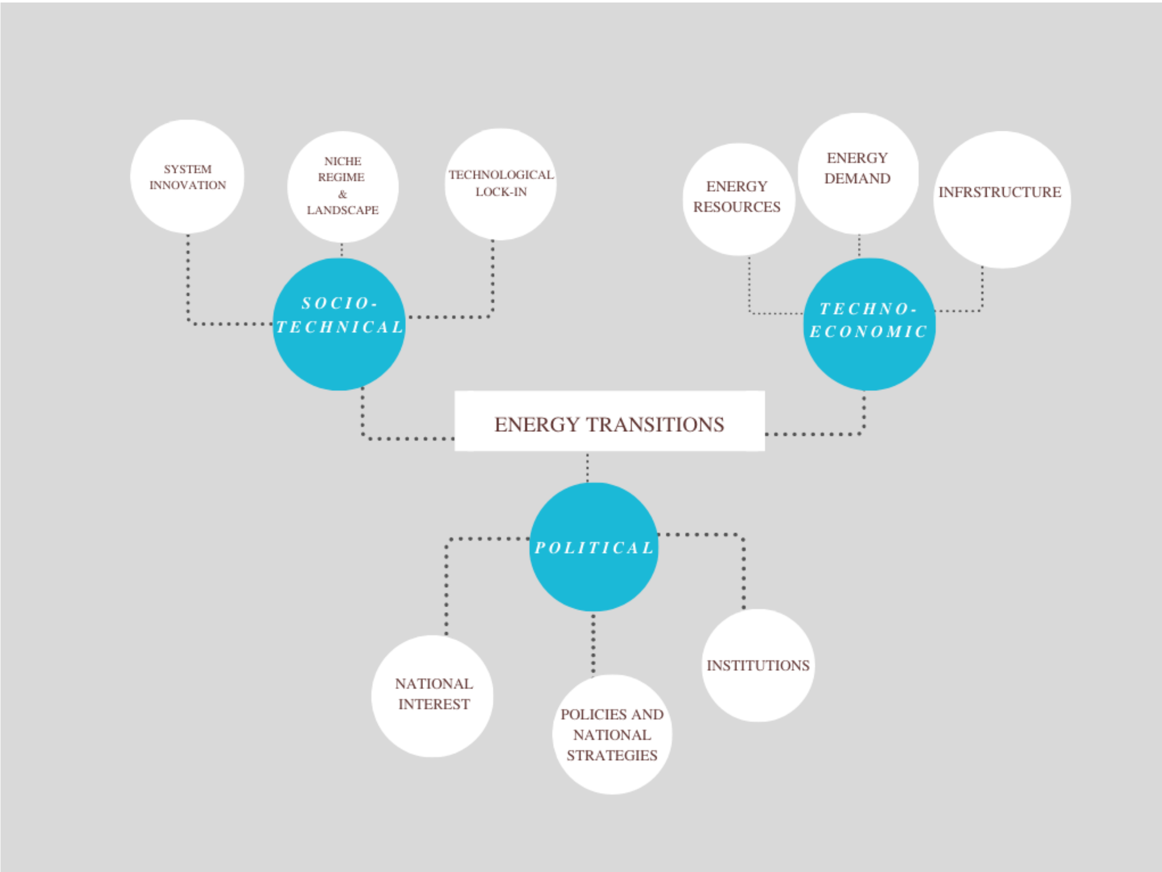
In 2018, the academic journal Energy Research and Social Science published a "common language" by Cherp et al. (2018) which proposed a common dialogue between disciplines to communicate about energy transitions. This was introduced as a meta-theoretical framework consisting of three top-level variables within national energy transitions: techno-economic, political and socio-technical perspectives. Energy transitions at a national level have historically involved different types of changes. According to this theory, the first type involves changes in the energy flows associated with energy "production" and "consumption", coordinated through energy markets. The second comprises changes in the technologies used for extracting energy and transforming the way it is utilized. The third type encompasses changes in the policies that regulate the socio-political role of energy systems, for instance to reduce poverty or modernize a country. Meta-Theoretical Framework theory (Cherp et al., 2018) was published at an early stage of this thesis and is the overarching theory for this research. This is due to the fact that the present study focuses on a single country case study (Mexico). The conceptualisation of a nation state is that they have the most obvious mandate to govern an energy system. It is at the national level that some of the most significant decisions to steer energy are and will be made; successive governments therefore play a vital role in defining energy transition strategies[11].

National energy transitions have historically involved different types of changes. According to this theory, the first has been changes in the energy flows associated with energy "production" and "consumption" coordinated through energy markets. The second has been changes in technologies used for extracting and transforming the way of utilizing energy. The third has been changes in policies regulating the socio-political role of the energy systems, for instance

[11] Davidsson explains that emerging economies follow a centralized approach in policy making. He argues that energy supply shortages, poor or non-existent infrastructure and subsidized end-user prices are some key direct challenges developing economies face to implement structural changes in energy systems (Davidsson, 2014).

to reduce poverty or modernize a country (Cherp et al., 2018). Independent fields of social science help us to understand sustainable energy transformations but fail to enable dialogue between perspectives. The three perspectives on national energy transitions can be summarized as follows;

Figure 3. Three perspectives on energy transitions at a national level. Source: Author's own adapted from Cherp. et al., 2018



Techno-economic systems are defined by energy flows associated with energy extraction, conversion and use processes involved in energy production and consumption as coordinated by energy markets (Cherp et al., 2018:178). As an example, techno-economic systems include the generation of energy, transmission of electricity through grids, petrol stations, fossil fuel deposits, light energy converted into electricity, transportation of oil, coal and gas from power plants, as well as final energy conversion in heating, light bulbs, cars, televisions, refrigerators, etc.

Systems of political action, influence energy-related policies are affected by decisions taken in the domains of society, environment, economy and international relations. In other words, a large number of actors are involved within the political perspective (Kuzemko et al., 2016). The strategies used by these actors should constantly be monitored to understand path dependency and lock-ins to ensure that interests are secured.

Sociotechnical systems are delineated by knowledge, practices and networks associated with energy technologies. It shows how the system is organized and will allow innovation to make a breakthrough (Hess and Sovacool, 2020).

Altogether, the three perspectives focus on individuals, markets, institutional rules and structures, practices and learnings that evolve over time, contributing to how the system is organized. The following section will introduce the existing Mexican energy system using the three perspectives on national energy transitions. The aim of the following section is to illustrate a transition as a multidisciplinary process.

3.2 From a Political Perspective

Similar to other world regions, Mexico experienced important reforms in the energy sector in power, gas and oil segments during the 1990s. Prior to 2014, the Mexican electricity system was solely owned and operated by the state under the Federal Electricity Commission (CFE). Currently, under the Electric Industry Law (RES grid integration), the state-owned monopoly has been abolished. With the strong intervention of the public sector, the Mexican government recognized the economic and strategic importance of electricity. Development of the electricity regulatory framework, interconnection, standardisation and large-scale investment became a trend in the past decade (see Figure 1). However, the most recent phase of market liberalisation started in 2013, with the energy reform being introduced by former President Enrique Peña Nieto. There was a strong desire for private investment and increased efficiency through competition. Independent investors, including international companies, started to engage in power generation and to sell energy in a competitive wholesale market organized by the independent entity CENACE (National Energy Control Centre). CENACE serves as the electric grid and market operator. The purpose of this institution is to promote competition and efficiency, delivering enough capacity for consumers[12]. Before the 2018 presidential elections, the energy regulator centre was in charge of many policy issues. The Mexican government was taking a more "hands-off approach" in order to increase competition and promote market-principles within the electricity system. This is where promotion of large-scale investment in low carbon generation, storage, interconnection, smart grids and an overall response to the high demand for electricity became a priority in Mexico's political agenda.

Figure 4. Increment on Renewable Energy investment in Latin America by country in 2017 and change from 2016. Author based on data source; Bloomberg New Energy Finance, 2018, p.30

[12] The Congress of the Union approved in 2013 the Energy Reform where articles 25, 26 and 27 of the Constitution were modified to allow the participation of private firms in the energy sector.

Therefore, foreign investments in renewables increased 810% in 2017 (Bloomberg New Energy Finance, 2018*)*. The fact that renewable energy infrastructure, also known as radical innovation[13], was aggressively implemented in the Mexican market leads is because of two reasons: the first one being a result of high-level decision makers imposing policies or instruments due to a strong liberalisation; the second being that society is consuming more energy, and social pressures are being imposed on existing energy systems. Tensions began to arise between political powers when the energy reform was implemented in 2013 by former Mexican presidents from both conservative parties: the Institutional Revolutionary Party (PRI) and the National Action Party (PAN) with the new elected leftist president Andres Manuel Lopez Obrador from National Regeneration Movement (MORENA). The shift in political position from right to left was a response by society to the need to urgently revise the objectives of previous administrations (see Chapter 5). The former strategy focused mainly on market liberalisation whilst currently it has a focus around security and sovereignty. This tension has led to extensive re-regulation with a new electricity reform approved on February 24th, 2021.

The electricity system is a single vast machine (Petterson, 2007); electricity as we use it is not a quantity, much less a substance or a commodity. Electricity is a process where power and politics play an important role. The following table indicates the general electricity industry elements and characteristics from generation to retail.

Table 6. Electricity Industry Elements in Mexico. *Source: Author*

Generation	Potentially Competitive
Power stations (centralised or distributed)	

[13] Renewable energy infrastructure is considered as radical innovation.

Transmission	Natural Monopoly
High voltage network, long distance transport	
Distribution	Natural Monopoly
Lower voltage network, shorter distance transport	
Retail (Supply)	Potentially Competitive
Buy from generators in the wholesale market, sell to customers in the retail market, meter and bill customers, pay for use of network.	

It is generally believed that historical decisions in previous administrations have led us to the policy directions made today, thus leading to a path dependency and systems lock-in. Path dependency argues that decisions do not happen randomly but instead are limited by decisions made in the past. There is a link between historical events and today's decisions taken by the Mexican administration. Choices in the past may leave society locked-in, the argument goes, and the cost of evolution to a new system exceeds the immediate gains, leading to a system lock-in. In this way, path dependency and lock-in will act as barriers to technological innovations. As Geels and Turnheim (2012) argue, path dependency occurs due to lock-in mechanisms that are mutually reinforcing and intricate. These mechanisms can include infrastructure, investments, subsidies, behavioural patterns regulations, core beliefs, technical knowledge, etc. This means there are serious implications to consider with respect to path dependency and systems lock-in.

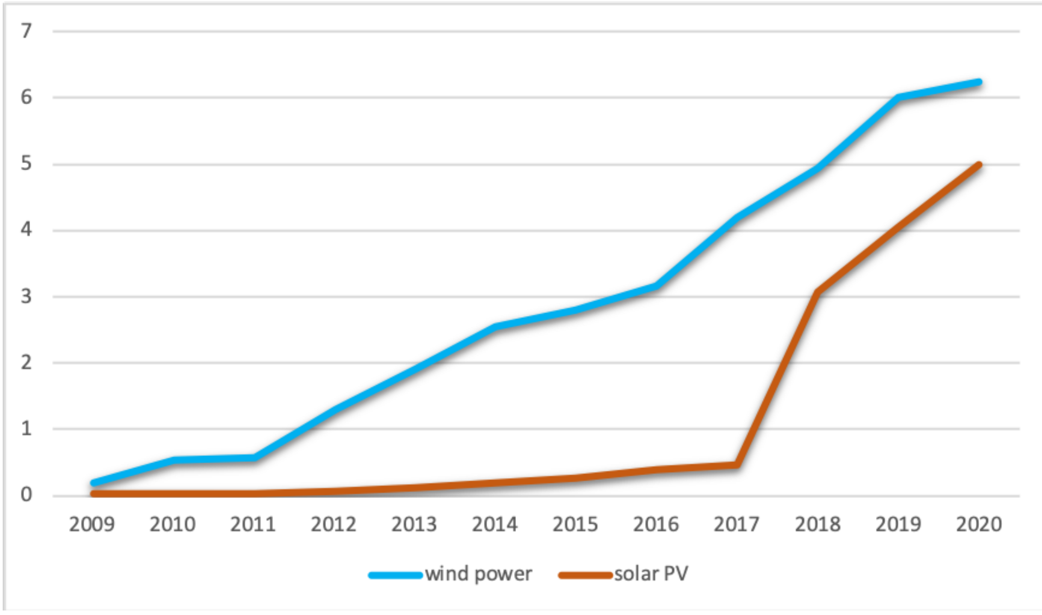
When it comes to policy, countries like Mexico follow a centralized approach to decision making where government plays a vital role in defining the energy transition strategy. Policy makers have a very important role in governing energy transitions in Mexico. Most of the time decisions are concerned with how policies will be promoted, reach more people, be easily available, or the promotion of a certain type of technology in the market. However, as the findings of this research indicate (Chapters 4 and 5), system lock-in represents risks in the transition dynamics such as institutionalised corruption, environmental and cultural core beliefs. The following section will explore from a techno-economic perspective how current policies are interpreted by different sets of actors and stakeholders; how investment decisions are taken by the government; and how innovation is shaped by society. Altogether, it provides a more comprehensive picture of how the transition may move forwards in terms of structural change.

3.3 From a Techno-economic Perspective

Techno-economic approaches in energy studies are crucial for analyzing and managing low-carbon transitions, but since transitions are disruptive, contested and non-linear, they cannot be reduced to a technical challenge nor driven by solely financial incentives (Geels et al., 2017). Investment in electricity generation sources is a risky business. This is because investors need to estimate return on investment, taking into account multiple risks and uncertainties such as policy, technical and financial. This requires forecasts of demand, forecasts of future fuel prices, influence of government policy, simulation of the likely operating pattern of the new plant (costs and revenue) and finally, and most importantly, assumptions about local and future generational behaviour towards the investment. Investors and analysts use sophisticated models to do this (see Chapter 5). Nevertheless, if local actors do not share the same positive perception of new technological entrants, tensions will rise and contradictions will be carried out. Risks can appear too high to incentivise investment on renewable technologies. Additionally, in terms of policy, there is little knowledge about how to create transformation-oriented innovation policy. From a techno-economic perspective, policy makers will support a specific source of energy based on a cost-benefit analysis. It focuses on rational decision making based on costs and benefits and views of markets as driving technology and infrastructure (Edomah, 2020, p.36). Energy technology decisions under such perspectives are all about economic and cost considerations. However, questions arise from the current electricity system and the techno-economic perspective. If decisions, policies and bills are made based on benefits outweighing the costs, then society is seen as part of that economic process. It can be argued that the techno-economic perspective does not sufficiently question what is driving the energy infrastructure and technological change.

Chapter 4 demonstrates that culture, beliefs and attitudes towards new technologies, influence people's practices which, in turn, impact supply, affecting local infrastructure choices. Under a transition studies lens, renewable energy could be labelled as a promising solution to environmental degradation (e.g. climate change, improving air quality, environmental degradation). This in turn, politically legitimizes the renewable energy development discourse. When this happens, actors at the regime level consider serious investment and implement policies to facilitate investors to develop the sector, seeing it as a mandatory step for a low-carbon energy future.

Figure 5. Historical development of installed capacity wind and solar power in Mexico (2009-2020). *Author. Data source: Asociación Mexicana de Energía Eólica (Amdee) and solar power capacity, data provided by Secretaría de Energía (SENER).*



The historical development of installed capacity wind and solar power in Mexico increased dramatically in the past years due to foreign investment and market liberalisation (see Figure 1). The last nine years have seen significant progress in Mexican wind and solar photovoltaic (PV) developments and its total installed capacity. Nevertheless, certain actions by the current government appear to be contradictory. From 2014 to 2018 we can observe an aggressive promotion of renewable energy investments and a package of laws to promote a lower emission economic model. Then, in 2018, after president Andrés Manuel López Obrador (AMLO) was elected, several energy projects such as the interconnection line between the State of Oaxaca and Mexico City, were suspended. In the same year, the General Director of the Federal Electricity Commission Manuel Barlett, announced that Mexico continued to consider coal a viable option for future electricity projects as it was low cost (Press Conference, 2019). The strategy put in place by AMLO's administration is to revitalize the country's energy industry and to recover energy self-sufficiency as a prime goal for national security (DOF, 2020). On March 2019, Manuel Barlett made the following announcement:

"*The issue of clean energies [wind and solar PV] is that they are being promoted by saying they are the cheapest option, and that is a lie. Wind and solar PV are very expensive, it is not true that they are cheap.*" (Press Conference, 2019)

The larger baseload[14] electricity includes coal, gas, biomass, geothermal and hydro, while dispatchable[15] electricity is sourced from coal, gas, hydro, oil, geothermal and biomass. This energy is centrally generated and then transmitted and distributed to homes and businesses. Even though the share of low carbon energy as a source for the electricity system is increasing, from the techno-economic perspective, the Mexican electricity system will be driven by rational choices which underpin an economic process. Hence, the energy supply infrastructure and the share by source of technology will have a different directionality in terms of system change. Changes in technologies are one of the three perspectives studied in this research on Mexican energy transitions. Thus, we can conceptualize that a techno-economic system is defined by energy flows associated with energy extraction, conversion and use processes involved in energy production and consumption, as coordinated by energy markets (Cherp et al., 2018).

3.4 From a Socio-technical Perspective

The socio-technical perspective includes one major strand of literature and research relevant to energy transitions. Geels et al., (2016) refers to it as socio-technical transition. As seen in Chapter 2, the roots of this strand of literature comes from evolutionary economics and historical macro-perspectives with actor-based micro-economic (Bridge et al., 2013: 243). The

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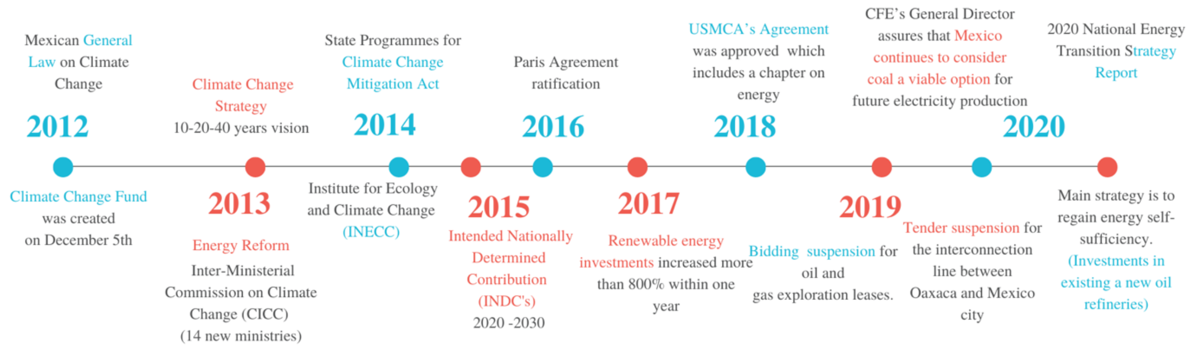
[14] Baseload is electricity that is produced a constant rate and whose power output is not quickly adjustable as compared to dispatchable electricity sources (e. g. nuclear power stations).

[15] Dispatchable is electricity sources that can be generated at varying power outputs. For example, at times of high electricity demand these sources can be adjusted to increase or decrease relatively quickly (e.g. hydroelectricity).

central unit is the socio-technical regime, defined as a shared set of rules and cultural routines embedded in socio-technical systems (Schot et al., 2016). These regimes are able to adjust to external pressures or internal disruptions and are considered stable and resilient entities. According to Cherp et al. (2018), in order to survive, regimes may foster or even block innovations that threaten their stability. This can explain lock-in and path dependency, when certain innovations are hindered just because they are not compatible with the dominant regime (Unruh, 2000). Socio-technical transition analysis is specifically interested in innovations in the niche and within a multi-level perspective approach, one of the most influential frameworks to analyse such phenomena.

In the case of Mexico, the socio-technical regime includes environmental institutions, policies and regulations associated with the electricity system. Today, Mexico has strong environmental legislation and has created institutions such as the Secretariat of Environment and Natural Resources, and other agencies in the environmental sector.

Figure 6. Improvements to the Mexican Environmental Framework over the last nine years (2012-2020). *Source: Author's illustration*



As explained in Chapter 2, the multi-level perspective (MLP) is one of the most commonly used holistic transition theories that focuses on change in institutional actors and structures at three analytical levels. As explained before, MLP is just one methodological approach out of several to understand transition dynamics. MLP research focuses on understanding the transition process whereas other popular approaches such as transition management (TM) are more focused on how to steer technological innovations (Genus & Coles, 2008).

The MLP examines a transition at three levels:

Niche – operates at the micro level which is free from excessive external pressures. One of its characteristics is its regulatory framework which acts as a safe environment for developing new technology or innovations.

Regime – these host the largest number of actors with its interests such as social groups, stakeholders, policy makers, etc. It is found at the meso-level of the system structure.

Landscape – is influenced by external economic, social, cultural and environmental pressures.

In this way, Mexico's regime (meso-level) has followed up on its international commitments with a coherent domestic climate agenda composed of: laws to promote a lower emissions model; aggressive promotion of renewable energy developments; and modernisation of electricity infrastructure. From 2018, there was a shift in the national strategy whereby energy security came to the forefront of the national agenda.

In order to illustrate the abovementioned levels, the following figure represents the number of actors located at the niche, regime and landscape levels:

Figure 7. Main Stakeholders in Mexico's Electricity System. *Source: Author's illustration*

The electricity supply industry in Mexico is currently dominated by a few power producers, connected to the national, high voltage transmission network that distributes electricity to communities. End-users rely on this electricity to power lights, appliances, etc. The Mexican energy system is complex as it relies on a number of different stakeholders. Each energy source or end-use has a range of implications with respect to political, social, economic and environmental impacts. Widespread learning and behavioural changes are required to understand the pathway that the transition will follow.

According to Geels (2004), a transition happens when internal momentum is maintained from the lower levels which is represented by several interests aligned and fine-tuned with each other. At the same time, multiple developments are needed. Technological innovations are not enough to direct change within a system; there are other elements such as costs and market shares

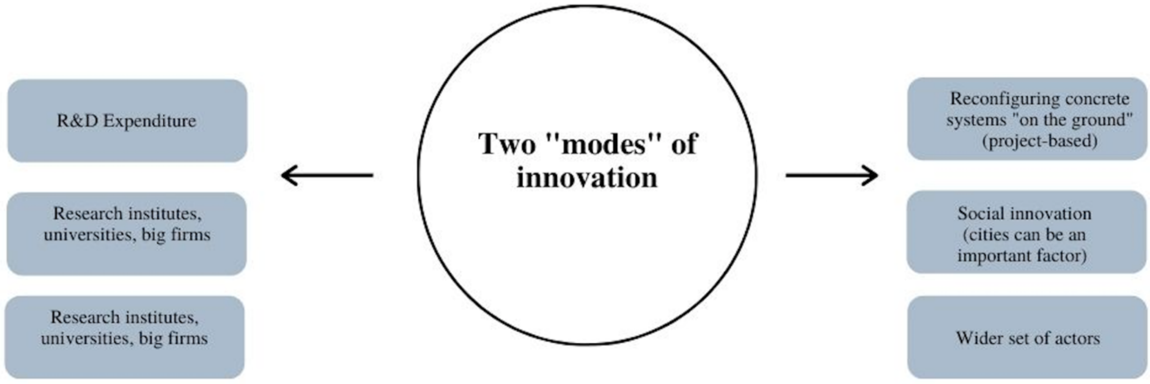
(Geels, 2011). For a transition to happen, learning elements have to be obtained from using the the mode focused on scientific and technology-based innovation (STI) vs. the mode based on learning-by-doing, by-using and by-interacting (DUI) (Jensen et al., 2007).

- STI (Science, Technology and Innovation) – This is the dominant mode of innovation where big actors, namely, research institutes, firms and universities. play a main role in the market. This mode represents a conservative approach to innovation, relying mainly on research and development (R&D).

- DUI (Doing, Using and Interacting) – This mode of innovation, as its name suggests, relies on learning and interacting with concrete systems on the ground. Technological innovations are not necessarily high-tech; however, they involve a large number of stakeholders such as consumers, big firms, policy makers, etc.

STI develops a relevant output based on high R&D expenditure, including investments in highly skilled scientific human resources, infrastructure and advanced technologies. By contrast, the DUI innovation mode stresses the importance of practice and interaction-based innovation that relies on learning by doing, by using and by interacting. These practices typically generate a type of synthetic knowledge based in a large number of engineering-based industries, such as machine tools, automotive and energy among others (Parrilli et al., 2016, p.748). The STI innovation mode creates high hopes relying on the big players. These innovations, if achieved, will depend on the interests of the players behind the outcomes or as (Geels et al., 2004) argues, it can take longer time for these innovations to come out of a laboratory and in some cases, they will arrive too late.

Figure 8. Two Modes of Innovation. Source: adapted from Jensen et al. (2007)



According to Jensen et al. (2007), the DUI innovation mode is crucial to successful innovation. This kind of knowledge is acquired for the most part by the individual facing on-going changes that confront them with new problems. Learning by doing and learning by interacting results in “local” knowledge interacting as part of the DUI mode. DUI may also be seen as a mechanism to turn local knowledge into global knowledge (Christensen & Lundvall, 2004). The continuation of previous innovations aligned with experiences, learnings and new knowledge, will continue to progress over time. For the economy as a whole, a specific sector may become the one that through interactive learning with a diverse set of users generalizes local knowledge and diffuses it widely in the economy (Jensen et al. 2007). In this way, we can conclude that the focus should not only be on direct gain but rather, on the learning process and the knowledge gathered to build up to the next step.

Table 7. Stages of technological development. Source: adapted from Grübler et al., (1999: 249)

Stage of Innovation	Mechanism	Learning rate by policy makers

Invention	Idea and knowledge generation, breakthroughs; basic research	Hard to measure
Innovation	Applied research, development, and demonstration R&D projects.	Hard to measure, high in learning
Market Commercialization	Identification of special niche application, close relationship between suppliers and users, learning by doing.	20 - 40%
Diffusion	Standardization and mass production; economies of scale.	10 – 30%
Saturation	Exhaustion of improvement potentials and scale economies; arrival of more efficient competitors into markets.	Severe competition

3.5 Integrating Science and Technology Studies

As we can observe in the section above, the social science energy research field utilizes a wide range of theoretical bases from different disciplines such as economics, innovation studies, sociology, etc.; thus, the necessity for concepts from a discipline known as Science and

Technology Studies (STS) or alternatively, "science, technology and society". Simultaneously, theoretical frameworks associated with topics on energy and climate with those STS are becoming increasingly prominent in social science energy research (Hess & Sovacool 2020; Longhurst et al. 2019; Hess 2015). Science and Technology Studies (STS), also known as Science, Technology and Society studies, provides the theoretical background to DUI and STI innovation modes. In addition, STS is important because the socio-technical transitions literature stems from the sociology of technology and innovation studies (Geels, 2002, p.1257). The emergence of STS as an academic field started in the mid-1960s and has grown through the 1980s and finally, found a nexus between society and technology in the early 1990s, with work on electricity and mobility systems in particular (see work of Wacjman 1991; Wynne 1996). As we can see, this academic field is extensive and robust, and there are a number of books and handbooks that provide a detailed understanding of this field, at an introductory level (see; Hess, 1997; Felt et al., 2017).

Nevertheless, this section begins with providing a basic understanding of STS as a field to identify those aspects that are relevant to the social science research on energy. This interdisciplinary field has always included energy among its dominant topics and contemporary concepts have been developed mainly among the energy related research area of STS. As we know today, two separate streams of literature have developed, one analysing the social, environmental and political impact of technology and the other focused mostly on the analysis of science as an institution that rejected ideas about scientific knowledge changes (Merton, 1973). In the following years, there was a shift from separate analyses being pursued in two disciplines to the integration of science and technology research with an emphasis on the principles of sociology scientific knowledge. The idea behind this argument is that knowledge in science has to engage with social aspects. In other words, it has to be based on evidence that includes conflicting perspectives rather than a process that can be solved in a formulaic way through a single experiment (Hess & Sovacool, 2020). This means that scientific evidence is subject to misinterpretation over its methods used and results obtained. One of the first applications of this new approach was the "interests" analysis in the political field of early twentieth-century Britain which recognised that technology is never purely technological but has an intrinsic social dimension. Conversely, the social is never purely social but is also technical, and that technologies only evolve or change because they are socially shaped in a certain way (Bijker & Law, 1992).

In other words, technologies are inseparable from social aspects. Science and technology studies (STS) view technologies as embedded into the social (Ellis et al., 2009:). With regards to renewable energy systems, Ellis et al. (2009) suggest that planning processes need to improve and that academic research needs to develop its methodologies to identify more effectively the social innovation (or re-composition) which is at the core of these processes (Ellis et al., 2009).

3.5 Electricity Law (LIE)

The Electric Industry Law (LIE) was published on August 11th, 2014 and the first national auction to sell and distribute electric power for private companies into the grid was awarded to eleven different companies. It was the first time that private investors could participate in Mexican energy sector. As a result, in 2016 twenty-three companies received contracts to develop wind and power parks. Finally, the last auctions took place in 2017 and concluded in 2018 with the change of administration and the new national strategy.

The public transmission and distribution of electric energy is reserved to the state and overseen by the public regulatory the National Energy Control Centre (CENACE) created in August

2017. CENACE is the operator of the national electric system, operations and market regulations.

The current governmental policy objective from 2018 until 2024 is to strengthen the national energy sector in all of its value chain, this includes improving the existing power generation infrastructure including The Federal Electricity Commission as the main electricity generator in Mexico. This is being done by prioritizing the production and consumption of national energy resources and decreasing electric inputs coming from wind technologies and photovoltaic sources as they are in majority privately owned by foreigner companies. The implementation of new policies has resulted in international opposition, private companies have filed constitutional appeals against the national strategy. Final decision regarding the constitutionality on domestic measures are yet to be decided by federal courts.

Regulatory framework is the package of laws and regulations governing the national energy sector. These includes the Electricity Industry Act, The Federal Electricity Commission (CFE) law, criteria for granting Clean Energy Certificates. The regulatory governmental authorities for the electricity sector in Mexico includes four main bodies, the Ministry of Energy (*Secretaría de Energía*) (SENER), which is responsible, among other things for law enforcement, supervision and energy policy; the Energy Regulatory Commission (*Comisión Reguladora de Energía)* (CRE), this issues permits related to energy generation, distribution and transmission; The Wholesale electricity market is managed by CENACE (*Centro Nacional de Control de la Energía*) and finally, the Ministry of Natural Resources and Environment (*Secretaría de Medio Ambiente y Recursos Naturales*) (SEMARNAT). Other areas such as safety, health, labor related matters are regulated by federal authorities.

The main players involved in the electricity system (from generation, transmission, distribution) are mainly the Federal Electricity Commission (CFE) through its subsidiaries and private companies with permits to take part on mainly on electricity generation activities. The public services related to the transmission and distribution are controlled exclusively by the Mexican state. Matters related to the wholesale electricity markets and the national electricity system are carried out by CENACE and overlooked by the Electric Industry Law. Besides these governmental institutions, the main companies involved in Mexican energy activities are the following; Iberdrola Group, Enel Green Power Mexico S de RL de CV, SunPower System Mexico S de RL de CV, Energía Renovable de la Península, Recurrent Energy Mexico Development S de RL de CV, Aldesa Energias Renovables, IENOVA, Sol de Insurgentes S de RL de CV, Consorcio Energía Limpia, Photoemeris Sustentable SA de CV, Jinkosolar Investment PTE Ltd, Vega Solar 1, SAPI de CV, Energía Renovable del Istmo II.

Overall, the participate in more than one strategic activity of generation, transmission, distribution and retail. Even under the new electricity law (LIE) where the public transmission and distribution of electric energy is reserved to the Mexican Government certain companies have private distribution lines or can participate in distribution with a prior permit given by the relevant authority.

Chapter 4. Wind Power "La Venta"

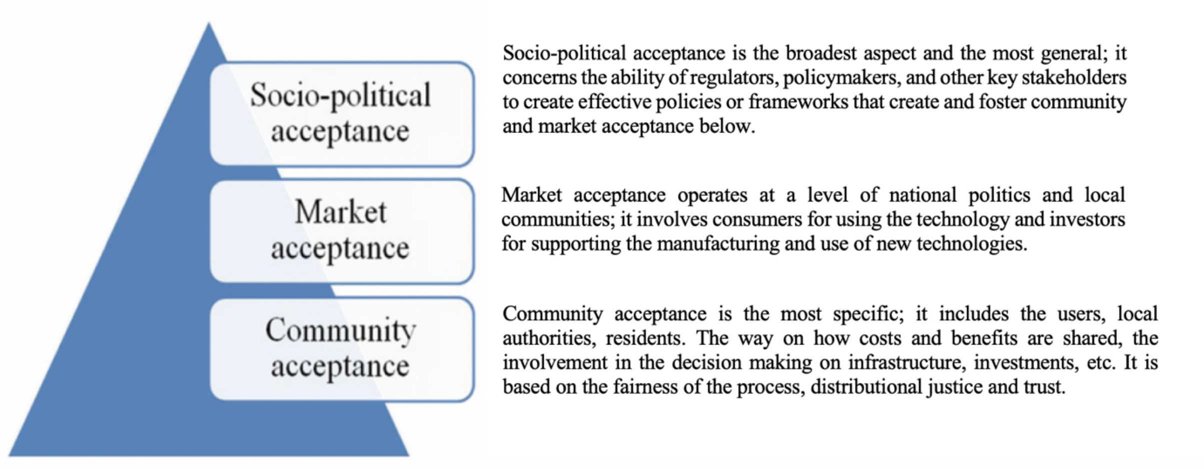
4.1 Emergence of Social Resistance

As discussed in Chapter 3, the increasing share of wind energy in Mexico set ambitious targets that promoted market liberalisation, supporting schemes and facilitating private investors within the sector. However, as wind energy started to spread across the country from 1994, it became clear that social resistance to wind projects could potentially be a barrier to the energy transition (Wüstenhagen, 2007; Avila-Calero 2017; Torres-Contreras, 2020). Conversely, history has proven that without certain obstacles such as public opposition, political or social factors, many great changes in a system would not have been possible. These examples include electrical modernization in the United States: according to Tobey's (1996) analysis, the expansion of hydroelectric power might never have been possible if it was not for the coal shortages and housing crisis during the Great Depression. Similarly, Gabrielle Hecht (1998) posits that the pursuit of nuclear power in France would not have happened without the emergence of "national identity" in France after World War II. A central argument in her book is that engineers and workers shaped practices and technological artefacts in an effort to implement the specific political and cultural programmes of the time. While these and many other historical publications consider social pressures and public opposition behind shifts in national energy policies, they leave unanswered questions about how social resistance emerges and impacts energy policies. In this study, I address the question as "How does social resistance to energy system change emerge, and what are its main influences/pressures in the case of Mexico?" In response, and due to the limitations of this research, this chapter explores the factors behind the emergence of social resistance to and acceptance of renewable energy projects in Mexico through the La Venta case study.

The chapter begins by conceptualising social resistance. It introduces the three dimensions of renewable energy acceptance developed by Sovacool et al. (2012) and is followed by an in-depth analysis of the first wind farm in Mexico to provide some context. Due to space limitations of this research, only the most important aspects of the case are discussed. The aim of this section is to showcase the findings behind the emergence of social resistance in the south of Mexico. As discussed in Chapter 2, the findings rely strongly on semi-structured interviews and secondary data. The chapter then summarizes the key findings, identifying five aspects of social resistance, all focused on the rejection of renewables: (1) Collision Risk and Environmental Implication; (2) Displacement of Land and Habitat Modification; (3) Sense of Ownership; (4) Politics of Free and Well-informed Consultations (5) Technological Design. The concluding argument is that social resistance emerges as a lack of unity or shared expectations along three main dimensions: socio-political, market and community.

Accordingly, social resistance occurs when there is limited "acceptance" of a new entrant or a change. When social acceptance is weak, technology in the niche does not flow in the same direction and cannot make a breakthrough. This research conceptualises social resistance as the counterpoint to "social acceptance". Batel et al. (2013) define social acceptance as a positive attitude towards a technology or measure which leads to a supporting behaviour, if needed or requested, counteracting the resistance of others (Batel et al., 2013). Failure to socially "accept" a renewable energy development will cause a reaction towards the technology. Opposition to wind farms in Mexico can be seen as part of the historical struggle of communities against governmental initiatives to introduce clean energy technologies. Building social "acceptance" is a concept that includes a positive response to something; it refers to the act of accepting and supporting a technology or a project, rather than merely tolerating it. Referring to wind energy, Sovacool et al., (2012) propose three social dimensions to social acceptance consisting of the market, socio-politics and community.

Figure 9. Three dimensions of Renewable Energy Acceptance. *Source: Sovacool et al. (2012).*



The lower level of the pyramid is represented by community factors, followed by the market which operates at the meso-level and finally, the socio-political factors can be found at the top where institutions play a crucial role in aligning expectations with society. The importance of expectations for collective actions among parties is widely recognized in the transition literature (Schot & Geels, 2008; Budde et al., 2012). In this way, expectations can generate external pressures which, together with alignment with stakeholders' expectations, can be crucial for niche actors to expand their social network and build internal momentum for niche acceleration (Schot and Geels, 2008). Before discussing social resistance in relation to actor expectations in more detail and to answer the question systematically, the case study is presented as a clear illustration.

4.2 Wind Power at the "Isthmus of Tehuantepec"

The first wind power plant in Mexico, known as La Venta I, was built in the state of Oaxaca in 1994. Specifically, it is situated in the ejido La Venta, in the municipality of Juchitán de Zaragoza, which is within the largest geographical region of the state of Oaxaca named Isthmus of Tehuantepec. To have a better geographical understanding, the Isthmus of Tehuantepec represents the shortest route between the Gulf of Mexico (Atlantic Ocean) and the Gulf of

Tehuantepec (Pacific Ocean). Where the Sierra Madre breaks up, a plateau-like ridge has formed which has significant wind power potential. The main districts of Isthmus of Tehuantepec are Juchitán de Zaragoza, Tehuantepec, Salina Cruz, Matías Romero and Ciudad Ixtepec. The southern region of the Isthmus of Tehuantepec has the greatest wind energy potential and is where the majority of wind energy projects are located. As expected, this is an ideal location for large-scale wind exploitation. The first serious assessments on the quality of wind were carried out back in the 1980s. Although wind technologies were not installed until 1994, the Isthums of Tehuantepec was considered to be the major wind power potential in Mexico (Mendoza et al., 2020). Since then, the region has stood out as being excellent for developing wind energy projects. Between Juchitán and Tehuantepec, the population is composed almost wholly of native Zapoteca people; other indigenous habitants are the Huaves, Zoques, Chontales and Mixes. In terms of natural resources, this region is considered one of the greatest areas of biodiversity in the country.

4.3 First Wind Power Plant "La Venta I"

La Venta is an *ejido* founded in 1951 as a result of an agrarian conflict between the lands of Santo Domingo de Ingenio and Juchitán (Sitton et al., 2014). It was originally created during the government of former president Miguel Alemán Valdés. The creation of La Venta as an *ejido* sought to providefor and compensate a group of other *ejidatarios who were displaced as a result of the mega project* mega project Pan-American Highway, a network of roads across the American continent connecting Alaska and Patagonia. As a result of this political conflict, an area of 6,069 hectares of arable land was divided in the following way: 4,707 hectares were divided between 418 *ejidatarios*; 1,338 hectares were left for common use; and the rest was for specific use (Sitton et al., 2014, RAN 2018)[16]. In the first allocation of land, each *ejidatario* was provided with a maximum of 10 hectares. In the years up to 1954, new *ejidatarios* were added and received 20 hectares of land each (Torres-Contreras, 2020). A degree of uncertainty marked the years following land distribution, partly because the rules were not entirely clear and because a number of *ejidatarios* could apply for **multiple** property titles, becoming landholders. As highlighted by Binford (1985:184), “the person who obtained a piece of land was in the habit of fencing the terrains in order to protect their property, while others who were more prepared paid taxes to the tax office in order to acquire the right of property”. Therefore, unequal patterns of land distribution and ownership appeared from the beginning. An ejido can be conceptualized as a piece of land farmed communally under state support and as the resolution regarding the land stated back in the 1960s **it is understood that at** “communal land there exists no private property” (Binford, 1985). The resolution was made by the government to make it illegal to turn communal land into private property, which fuelled renewed discontent in the town. The federal government’s ban on private property ownership in the municipality of Juchitán de Zaragoza in 1964 caused dissent in the communities, especially among landholders, leading to the forming of committees against the federal government. In order to gain political support, the presidential candidate at the time visited the region and promised a solution to the land division. Once in office, President Diaz Ordaz introduced a presidential decree on March 31st 1966 that allowed 3,887 property titles (Binford, 1985). However, although these titles guaranteed the possession of communal land, they did not grant full ownership rights. For instance, the “owners” could use their designated land but could not cede it to third entities (Binford, 1985).

[16] There is an inconsistency on the exact number of hectares originally integrating the ejido of La Venta, this research considers these inconsistencies.

Without having entirely eradicated the communal system and after having reached an agreement on land ownership through the Agrarian reform in 1992, the Federal Government decided to develop the first wind farm in the country as a pilot project named La Venta I. The government promised economic development to the region. Groups of investors began to visit La Venta regularly in order to carry out wind quality tests with experts from NREL, USAID and CFE among others (Friede, 2016). The wind power plant was equipped with seven wind turbines from a Danish manufacturer known as Vestas. Each generator had a capacity of 225 kW and the towers were thirty meters high. The total capacity of energy production was of 1.5 MW (Tovar et al., 2007). The tender was managed by the Federal Electricity Commission (CFE) under a scheme known back then as the Public Financed Project (obra pública financeada). Even though the size of the wind farm was small compared to large-scale projects, La Venta I gathered sufficient information on the real performance of wind turbines and was considered a success. The outcomes registered by the seven turbines were so outstanding that only those installed in New Zealand presented similar generation values (Hiriart Le Bert, 1996). As the success story came to light, investors from all over the world visited the region to consider new developments and negotiate with the ejidatarios. These meetings envisioned a mega project consisting of a wind corridor covering 1,200 km2, supported by international investors, agencies and authorities (Elliott et al., 2004).

According to Torres-Contreras (2020), this situation led to land speculation where land prices rocketed from one day to the next. The average price for one hectare of land increased from 20,000 pesos (1,000 USD) to almost 250,000 (12,500 USD). As a consequence, ejidatarios considered leasing their lands to investors coming into the region. In parallel, there was pressure from potential investors to further divide territory in the region (Avila-Calero, 2017). As a consequence, the authorities introduced a simplified geometry of divided land to be imposed on the existing maps of agricultural fields, one which entirely ignored rivers, forests, villages, roads and private properties (Avila-Calero, 2017). After the pilot wind farm, the building of a large-scale project in the Isthmus of Tehuantepec took more than ten years. By the end of 2004, the Federal Electricity Commission (CFE) announced the construction of La Venta II with a total of 98 turbines, manufactured by Gamesa with a normal capacity of 83.3 MW.

4.4 "La Venta II" and the Wind Power Expansion

Between 2001 and 2004, a series of international reunions were organized by the World Bank, United Nations Development Programme (UNDP) and the Global Environment Facility (GEF), as part of a programme to help develop the Isthmus of Tehuantepec, referred to as the "International Colloquium on Wind Energy Development Opportunities in the Isthmus of Tehuantepec Wind Corridor (Zárate-Toledo et al., 2019). The main objective was to attract investors into the region and negotiate directly with the communities. President Felipe Calderón took office in December 2006 and that same year, the government launched an initiative to expand transmission infrastructure to connect wind farms to the national grid managed by the CFE. This public-private initiative had as an objective to expand transmission infrastructure and connect wind farms to the national grid. From this year on, the government started accepting new investment projects. According to Borja et al. (2005), during the first phase of development, their investors' and developers' principal concern was to convince local ejidatarios to lease their lands. To do so, national agencies such as the Procuraduría Agraria were created to help developers present the benefits to the communities. The Federal Electricity Commission (CFE) approached ejidatarios with the intention of renting their land for thirty years, with the possibility of renewal after the contract expired. Private companies and the CFE offered a compensation scheme that went as follows: 1,000 pesos (50 USD) per hectare for the right to use the wind; 13,000 pesos (655 USD) for the right to build infrastructure; and around 15,000 pesos (755 US) for windmills, according to generation capacity (Aviles-Hernandez & Olinco, 2008). The land leasing process created disagreement in the community and threatened the community organisation that had its foundation built on community ownership. This meant that wind companies would remove control of the lands from ejidatarios, without considering their environmental and community concerns. The pressure started to grow as attractive schemes for multinationals were introduced. For instance, two schemes were agreed upon: the independent power production (IPP) and the self-supply (SS). In the latter, the energy produced is directly supplied for commercial or industrial use, benefiting larger companies and then selling the surplus energy to the national grid. Through the independent power production (IPP), all energy is sold directly to CFE, making it a business for investors (SENER, 2017).

Wind energy generation capacity has grown steadily since 2006, with 82% of current capacity installed in the La Venta region (CRE, 2019). Following the self-supply scheme, private multinational firms such as Nestlé, Coca-Cola, Walmart, Nissan, etc., have benefited from the liberalisation measures of natural resources (Avila-Calero, 2017). All in all, 31 wind farms are currently in operation in the state of Oaxaca (Oaxaca Gob, 2020). The development of power plants in the region is led by private companies. Table 5 provides an overview of the main power plants built in recent decades. In order to elucidate the causes of growing social opposition to wind projects, the context wherein social discontent stems from has to be understood.

Table 8. Main Wind Power Plants on the Isthmus of Tehuantepec. *Source: Author's own with data from Energy Regulatory Commission (CRE) and (Oaxaca Gob, 2020).*

Project	Scheme	Developer (owner)	Capacity (MW)	Main Supply Destination
La Venta I	IIP	CFE	1.5	CFE
La Venta II	IIP	CFE	83.3	CFE
Oaxaca I, II, III, IV	IIP	CFE	405.6	CFE
Eurus	SS	Acciona Wind Power/ Cemex	250	CEMEX
Parque Eólicos de México I (La Ventosa)	SS	Iberdrola	79.9	Pemex; Volkswagen
Fuerza Eólica del Istmo	SS	Industrias Peñoles/ ClipperWind	80	Cementos Portland La Cruz Azul S.C.L. y Procesos Electrónics de México S.A. de C.V.
Eléctrica del Valle de México	SS	EDF- Energies Nouvelles-Mitsubishi	67	Wal-Mart Mexico
Bii Nee Stipa Energía Eólica	SS	Cisa-Gamesa	26.3	Nestlé; Gamesa; Jugos del Valle

Desarrollos Eólicos Mexicanos	SS	Demex	227	Bimbo; Suburbia; Wal-Mart
Gamesa Energía	SS	Gamesa	288	Banco Santander
Energía Alterna Istmeña	SS	Preneal México	215	Oxxo; Cervezería Cuahutñemoc Moctezuma
Fuerza y Energía Bii Hioxio	SS	Fenosa Renovables	227	Cementos Moctezuma, Chedrahui
Desarrollos Eólicos de Oaxaca (Piedra larga II)	SS	Renovalia Energy	137	Wal-Mart de Mexico; Suburbia
Eólica el Retiro	SS	Cisa/Grupo México	74	Industrias Minera México; Cinemex; Cinemas Lumiere
Energía Eólica Mareña S.A. de C.V.	SS	Preneal México	180	Oxxo

4.5 Main Players

With the construction of La Venta II in 2006, new social conflicts emerged. Before exploring the social conflicts and stakeholders' expectations, the following section will briefly explore the three main players in this case study.

1. Governmental bodies

Stakeholders and institutions from the three levels of government (local, state and federal) have participated in the promotion and development of wind power plants in the region from the beginning. It is interesting to note that after the first renewable developments (La Venta I, La Venta II, Oaxaca I-IV) were built by federal governmental agencies such as CFE and CRE, these agencies moved aside to make way for private investors to arrive and develop their own power plants, with the promise that there would be public distribution of renewable energy to the national grid. Overall, the municipal government has a minimal role behind wind project auctions as they are managed by the federal branch agencies. According to Juarez-Hernandez and Leon (2014), CFE has obstructed the adoption of community wind projects that could allow local ejidatarios and other social agents to become shareholders and thus receive access to a greater proportion of the benefits (Juarez-Hernandez and Leon, 2014). This is the case for several failed proposals, such as the one put forward by the community members of Ciudad Ixtepec, introduced in 2009, who proposed the idea of developing a communal wind power plant. Such a proposal would have created the opportunity for involvement and participation of communities. Due to the need for collective decision making and empowerment of communities, the first community-based proposal by a British company (Yansa Group) was rejected. The CFE later announced that the tender had been given to another private company developing a wind power plant named Sureste Phase I and II. After a series of community strikes and protests due to the unfavorable conditions offered by the company, the project was cancelled in 2013. The role assume by the CFE at the beginning of the energy transition is largely explained by policies having the objective of favouring private capital investments.

2. Wind Turbines Manufacturers, suppliers and developers.

Since the first wind power plant was built, private capital has been considered essential to developing the Mexican wind corridor. Private energy companies have acted as the protagonists of wind development in the region. That is why in 2005, the Mexican Wind Energy Association (AMDEE) was created to represent wind project developers against authorities, economic sectors and society in general. Together with political support and lobbying activities, AMDEE was behind legal and regulatory adjustments to ensure the profitability of wind energy projects (Juarez-Hernandez and Leon, 2014). Members and associates of AMDEE include transnational energy companies such as Energies Nouvelles, Gamesa, Vestas, Enel Green Power, etc. Wind energy companies often boast about the benefits and development their projects will bring to the local communities and make much of the amount of energy generated to number of households that could be potentially supplied with that energy in their promotional campaigns. However, the reality, based on the analysis, is that most of the energy produced in the region directly supplies private companies and none of the projects directly benefit the affected communities in terms of energy generation.

3. Local Communities

The first years of the development of the wind corridor have shaped local actors' views about wind projects. An increasing number of local communities have organized protests and movements against wind power projects. In general terms, the communities are cautionary regarding their cultural and communal way of life (Naumann and Rudolph, 2020). Some wind projects have been stopped due to a failure of consultation prior to the building of the project. For instance, Indigenous Zapotec activist Mariano Lopez stated that his community was not opposed to clean energy but only requested that the environment be respected (Naumann and Rudolph, 2020). Wind power development entails a variety of environmental and cultural concerns that need to be carefully addressed. The following section will explore the concerns behind social opposition to wind energy in order to understand the roots of social resistance.

4.6 Expectations of wind energy

At the beginning of the local resistance pathway, opposition was articulated throughout well-established institutions for decision-making (*ejido*[17]assemblies), existing social and political organisations as well emergent movements against wind power projects (Avila-Calero, 2017).

There are several factors associated with the discontent of residents towards the development of wind technologies and they vary depending on the geographical location of each project. For the La Venta case study, five main reasons behind social resistance to new wind technology were identified: collision risk and environmental implications; displacement of land and habitat modification; sense of ownership; politics of free consultation; management practices; and turbine design. The following section will briefly analyse these six concerns;

1. Collision Risk and Environmental Implications

[17] An *ejido or ejidatario* refers to community-based land tenure holders. Arising from the Mexican Revolution in 1910, the Constitution was reformed to explicitly recognize community-based land tenure and forbid commercial manufacturing, mining or petroleum companies from acquiring, holding or administering these rural properties.

Participants complained that the main ecological impact of wind-powered generators is the risk to endangered avifauna species which could die as a result of collision with moving turbines. Accidents occur when birds fail to manoeuvre their way around the wind turbine blades leading off the grid. Wind power represents a high risk for birds' mortality especially when wind farms are placed in their migratory routes (Barrios & Rodriguez, 2004). The collision is a direct cause of death and according to participants 1 and 6, one of the main concerns around loss of wildlife is the significant threat to endangered birds in Mexico. Several studies show that a large number of golden eagles are killed annually at Altamont, Northern California, as a result of collision with wind turbines (Drewitt & Langston, 2006). Another study in California showed that up to 42 percent of the golden eagle population near wind farms died within a year, with wind turbines responsible for their deaths (Hunt, 2002: 19). According to research by the conservation group SEO/Birdlife, every year in Spain, between 6 and 18 million birds and bats are killed by wind farms (Atienza et al., 2011). Given the fact that indigenous communities consider the golden eagle a sacred animal, a symbol of their land to whom they owe respect (interviewee 1), they will alert the community to any possible threat. These facts are of particular concern regarding social resistance to wind technologies. Residents in Mexico are worried about environmental degradation, especially the death of endemic birds (interviewees 1 and 6). According to participants of this study, local inhabitants have questioned engineers responsible for the wind technology design at La Venta about the risk of collision for birds when crossing the wind turbines. The answer given by the engineers was that "they [migratory birds] will have to fly around [the turbines]". This response is a clear example of how the project fails to consider local concerns, leading to discontent among local communities towards the development of wind energy. According to Clive Hambler, a biology lecturer at Oxford University, certain individuals in favour of clean energy simply tend to ignore the threat that wind farms represent to wildlife; they are so desperate to believe in renewable energy that they are in a state of denial (Hambler, 2016). Participants agreed that wind energy is one of the environmentally friendly options among all the energy sources available in the country. However, opinions on the negative impacts of wind turbines technology reported major direct wildlife impacts as the main cause of mortality from collisions. Overall, in this region it is claimed that based on the available evidence by participants show that the strategic position of wind parks contributes to a high number of wildlife habitat displacement and an increase in endangered bird's mortality.

2. Displacement of Land and Habitat Modification

The wind turbines, the noise, the vibration produced, and the electromagnetic fields represent a disturbance to wildlife. According to interviewee 7, this is an issue for residents, as communities struggle with witnessing the displacement of avifauna which is part of their ecosystem and culture. As a result, widespread opposition among inhabitants of La Venta and closer communities has increased in the past decades. Participant 3 added that habitat loss has proven to be a major issue during the construction of wind power plants and that in some cases, it is seen as a major threat in comparison to the daily operations of a wind farm. They suggested that the authorities do not take these concerns into consideration, accepting wind projects as long as they have economic benefits through the leasing of farmland: "The problem arises when only a few landowners are compensated rather an entire community." From the community point of view, Participants 16 and 7 agreed that factors related to distributional justice are outweighed by the benefits of clean technology. It has to be clear to residents how the costs and benefits are to be shared, as well as providing a resilient, well-organized process that enables them to participate in decision-making. Interviewee 16 stated that: "collaboration between stakeholders is needed to solve social discomfort". Furthermore, several participants agreed that the cooperation between different partners such as governments, researchers, ecologists, residents and private investors is necessary to facilitate "innovation" with an environmental or social approach. The involvement in this research among different bodies and levels indicates that sharing of resources (in order to communicate learnings of new innovations) can help to scale projects and to ensure mistakes previously made are not repeated**.** Large-scale projects or expensive technology can be co-founded rather than being limited to a single organisation fund. These findings indicate that the DUI innovation mode, as the participants describe it, is more likely to develop when there are shared goals. For example, Participant 10 reported that lobbying from conservation organisations or influential NGOs is necessary for developing appropriate sites that are crucial for minimising wildlife displacement.

3. Sense of Community Ownership

Due to the need for increasing public acceptance of wind technologies, new entrants need to establish community involvement and a close relationship with stakeholders from the early stages. The majority of participants in this research agreed that if a platform or a way of communicating and sharing interest among stakeholders had existed, Mexican citizens would have been more in favour of renewable technologies for development. This argument is sustained by the International Energy Agency (IEA) which stated that wind development that has failed to benefit local communities has increased opposition towards wind technologies (IEA, 2011). Participant 10 mentioned that Mexican citizens would be more in favour of wind farms if they profit from the development. Opportunity for local ownership is hailed as a factor that would increase community acceptance. However, whilst it is true that certain independent projects have promoted an inclusive development scheme that has helped women to create their own businesses and promoted community participation, these are exceptions. Participants 10 and 8 recommended that in order for the environment to be protected, communities should be involved, as this would ensure that their cultural heritage and legacy would be taken into consideration: “For us, since the establishment of our community in Juchitán de Zaragoza, to protecting the environment and wildlife is an incentive for us, particularly for our youth and future generations. We take care of our land, keeping the environment safe and clean. The resources are not ours alone, they belong to our children and their children.” The involvement of society is currently determined by compromises of each individual stakeholder and their interests in achieving sustainable development goals. Overall, it is indicative of this research that the democratic participation of residents and fair distribution of gain and losses is more likely to direct policy towards environmental protection.

According to the book, “How to be Danish?” by Patrick Kingsley, 16 out of 21 turbines located on the Island of Samso, are owned either by local co-operatives or individual farmers. This means that the excess energy generated by the turbines is sold back to the national grid. In this way, profits create a handy annual dividend for the locals. In other words, farmers and local landowners in countries such as Denmark benefit economically from the wind turbines. Danes involve local communities and 80% of wind turbines are co-owned by local groups (Kingsley, 2012).

4. Politics of Free and Well-informed Consultations.

The study findings show that discontent among residents close to the La Venta I project was because public and free information was not well managed by developers or authorities at any stage of the project. Specifically, in the early stages, the project failed to inform local communities about the environmental impacts. Respondent 10 agreed that community consultation is necessary to increase social acceptance. For instance, the Zapotec community sent a petition at the construction stage to the government claiming that the early consultation process had not been sufficiently informative (interviewee 10). The result is that potentially effective innovations in a given context may stall. Thus, in the learning process of the transition to renewable energy, the Mexican federal government must look into their policies and regulatory framework. Developers must provide comprehensive information to the people of the technical qualities of renewable projects such as turbines designs, installations sites, number and capacity of machinery.

5. Technology Design and Innovation

Technical innovation in turbine designs can lead to improved performance and improved environmental benefits, for example, the protection of avifauna or reduction in noise pollution. Additionally, it can lead to significant cost reductions. Interviewees 8 and 10 mentioned that improvements to the technological design of wind turbines should be tailor-made for each community, taking into account the environment in which it will operate. Specifications to be considered should include the environmental impacts, efficiency performances and geography (participants 8 and 10). Accordingly, for new entrants, the environment in which the technology is introduced can either be a barrier or driver. When technologies are designed to satisfy social factors such as environmental impacts, e.g., the displacement or collision of bird species, negative social resistance is likely to decrease. Participant 8 explained that the larger wind turbines are worse environmentally than developments with smaller turbines. A solution for participant 8, would be for policy to go hand-in-hand with regulations that protect the community’s interests. In this case, the government would prioritise the construction of small and medium turbines. The problem with new designs, according to participant 8, is that developers do not share their technological designs with local universities: “It is not well informed, they just bring their machines to our town, our engineers can repair them or understand; however, they are not part of the design or group of researchers.” He emphasised the importance of taking into consideration local factors when designing a model, such as local wind conditions (frequency of wind and intensity), the route of migratory birds and the efficiency of the connection between the power generated and the national electric system.

4.7 Data Collection and Analysis

Data collection included 20 semi-structured interviews with relevant actors from different levels (micro-level, meso-level, and macro-level); desk-based research in particular policy reports, news from relevant national journals and previous research. The interviews were conducted between March 2020 and August 2020. Using interviews to collect data on social resistance and expectations is challenging in a number of respects. For instance, individual bias due to previous events may affect perceptions of expectations and social opposition. Secondly, the number of participants was limited to twenty. To overcome these challenges, questionnaires were designed to cover a large timeframe in terms of energy developments. Additionally, certain questions were designed to be cross-checked with information given to identify alignment in expectations (see Appendix B). In developing the interview questions, the three dimensions of renewable energy acceptance were considered.

The secondary data included journal articles focusing on the electricity sector in the region of the Isthmus of Tehuantepec, historical archival data, annual reports on electricity power development produced in Mexico and news articles.

4.8 Conclusion

4.8.1 Weak alignment of expectations and social resistance

One important issue identified in this study is the lack of promotion of public policy that understands local-level expectations. The development of the wind sector that, among several objectives, takens on the task of innovation, can address local issues, including environmental degradation, information gaps and communal ownership. In other words, technical innovation could be genuinely shaped by the transition process. Historically, transitions have taken place in a timeframe of many years, even decades or centuries. In the region of the Isthmus of Tehuantepec, the transition to wind energy is still relatively recent and the learning curve has influenced national politics from neo-liberalism to a more conservative social democratic approach. There is certainly potential for wind exploitation in a country that favours a democratic participatory approach to the involvement of local communities, where residents can engage in the manufacture of renewable energy equipment, the rules and regulations of the sector, and come up with potential solutions and sustainable practices to address their concerns.

4.8.2 Strong alignment and niche acceleration

Literature on interest groups in the energy sector typically suggests that powerful interest groups, together with the larger capacity of economic potential and organisational capacity, are structurally more powerful than “weak” interest groups (Gründinger, 2017; Horváthová et al. 2019; Shen and Lyu, 2019). The evidence collated by this research proves that larger international companies and governmental agencies over the past twenty years lobbied for, and implemented, comprehensive change in energy and climate policies against the will of “weaker” interest groups. This research demonstrates that a strong alignment of expectations between stakeholders can provide niche acceleration, as explained in Chapter 2. When the benefits are shared among the community and communal ownership as well as their ways of life are respected, projects can be rather successful, such as the pilot wind power plants La Venta I and La Venta II that are owned by the federal government. The tipping point of general discontent came in 2006, when private companies with different interest groups began developing the region for private supply. In this research, different types of social resistance between niche and regime actors have been categorised into basic alignment patterns between expectations and social resistance[18]. This enables the focus to be on players' expectations and not only on the negative aspects of resistance to or tolerance of something, which will help to identify future developments at the three levels of national transition (Chapter 3).

Based on Truffer et al. (2008), Budde and Konrad (2019), and Yang et al. (2020) perceived expectations are at the three levels: landscape expectations refer to future of the future of the external environment as perceived by an actor, such as environmental issues or the communal way of life, which influences the long-term development of the system. Landscape-level expectations are at the meso-level and therefore tend to be more general compared to the other two levels; at this level, external momentum can guide the direction of transition (See Chapter 2).

Regime-level expectations consist of perceptions about the regime's capability (or lack of it) to adapt to internal tensions and crises or to external pressures and are located at the meso-level. If regime expectations become positive, for example, the stakeholders start to question regime

[18] Niche refers to the micro-level, regime refers to the meso-level and landscape to the macro-level. This research utilises the Multi-level perspective approach which is one of the main frameworks to understand transitions (see Chapter 2)

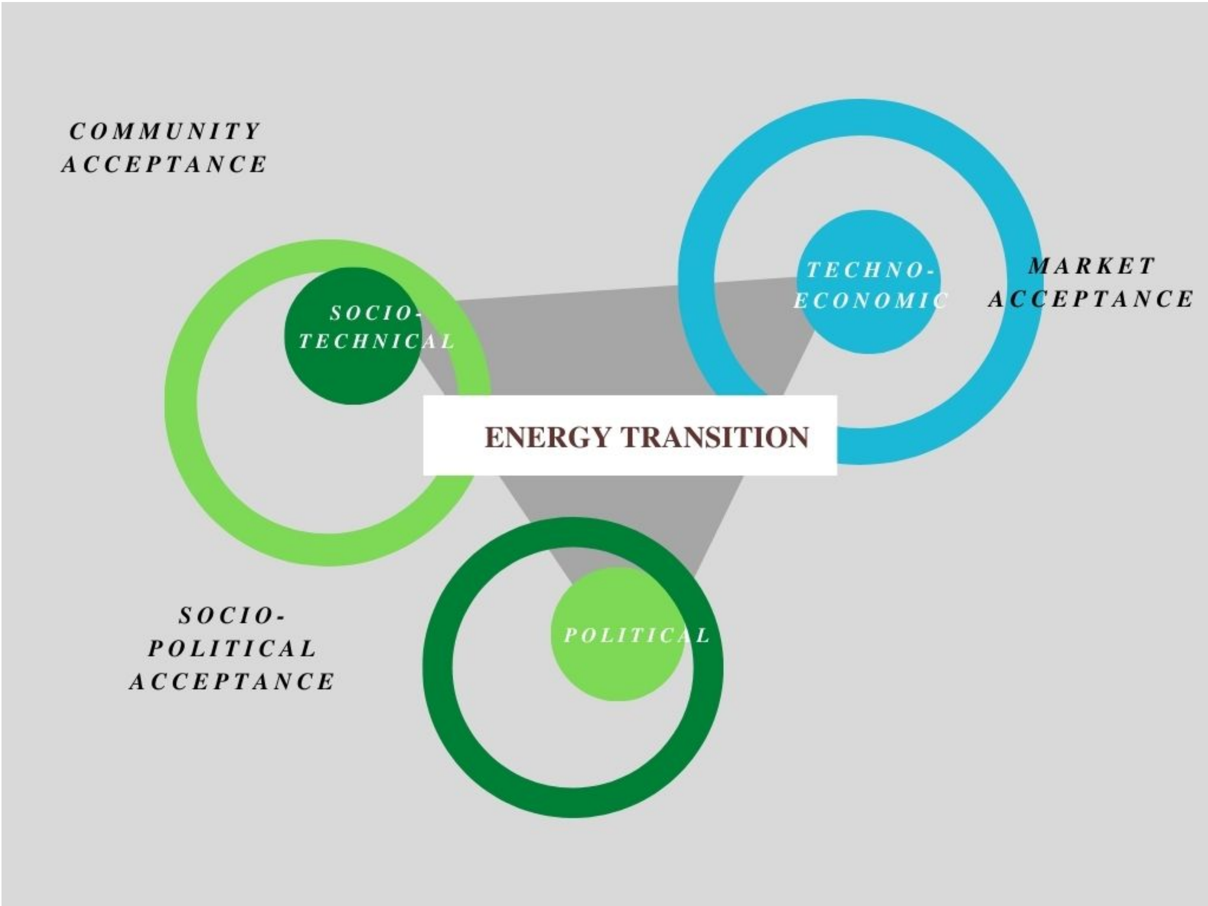
resilience; this will lead to regime destabilisation and contribute to niche development (Yang et al., 2020).

Niche-level expectations pertain to the future performance of the specific sociotechnical configurations of emerging technologies, such as the role of wind power in meeting energy demand, technology performance or the expected market competitive advantage. When weak, they cannot contribute to niche acceleration, thus hindering the transition. Expectations at this level are often more specific and visible compared to expectations at the other two levels (Yang et al., 2020).

Thus, social resistance to wind energy has three dimensions, socio-political, market and community. These are measured over the introduction of principles for community acceptance in wind power projects. These principles include openness by sharing all relevant information with the local community and stakeholder concerns; accountability through the ongoing process of monitoring, evaluation and participation; and flexibility by preparing for local requests and being open to modification (WISE Power Project, 2014).

In conclusion, Chapter 3 argues that energy transition at the national level requires more than technological implementation but must consider three perspectives on national energy transition (see Chapter 3 and Chapter 2) to understand the evolution of a system: socio-technical, techno-economic and political. As this section demonstrates, in order to make sure benefits are secure, with a strong alignment of expectations at the three levels, policy must consider the three perspectives on national energy transition together with the levels of the pyramid on social acceptance. The following image illustrates the conclusion of this chapter.

Figure 10. Social Acceptance of National Energy Transition. *Source: Author.*



Chapter 5. Solar Park Villanueva

The second case of this study is the proposed Villanueva Solar Power Plant located in the northern part of the country in the state of Coahuila, particularly at the *ejido* San Juan de Villanueva in the municipality of Viesca, 60 kilometres east of the city of Torreon, Mexico. Villanueva is a 754 MW solar photovoltaic (PV) power plant developed by the Italian company Enel Green Power (EGP). Commercial operations commenced in March 2018, making it the first solar power plant to be in operation since the introduction of the energy reform in 2013. The project is important due to its size and innovative construction, with more than 2.3 million solar panels spread across 2,400 ha. EGP have used advanced construction technologies such as full digitalisation and automation processes (NS Energy, 2020). The project was divided into two phases; Villanueva I with a capacity of 427 MW and Villanueva 3, with a capacity of 327 MW.

The following section analyses the context and provides a description of the conflict and mobilizations in form of social resistance to the project. To understand the system dynamics (see appendix b), a total of ten interviews were conducted specifically in relation to this case, five from the local-level and five from the macro-level. The rationale for the selection of this case study and the central question explored during this chapter are described in detail in Chapter 3. Here I address the question:

- How do global forces (landscape-level) influence the speed and directionality of the transition in Mexico?

The findings from Chapter 5 evidence that labour conflict coming from organisations and international institutions (from the macro-level) over contracting and salary payments emerge due to the lack of consistent application or neglect of formal rules at the regime-level (meso-level)[19]. On the other hand, issues arising from renewable energy developments also represent an opportunity for old pathways to evolve into more sustainable ones. Results suggests that breaches within the legal framework in energy projects allow international investors to abuse local outsourced companies. This Villanueva project illustrates the dynamics of energy transition in general and the barriers and drivers of a low-carbon energy transition in particular. In order to secure benefits for future or similar developments, there is much to learn from these specifics. After a contextual description of Villanueva Solar Plant, the findings regarding

[19] Chapter 2. Methodology explores the concepts of the Multi-level Perspective approach that describes three analytical levels

transition dynamics are presented. A cognitive map is provided to illustrate the patterns and relationships behind the transition dynamics. The chapter concludes by discussing the concept of transition dynamics.

5.1 Solar Energy Context

Mexico is a country with high solar radiation; yet up until the last decade, the exploitation of these resources was minimal. Currently, Mexico generates around 25% of its electrical supply from renewable energy sources (IRENA, 2020) with solar photovoltaics power generation showing important growth share in the sector. There are two types of solar technology mass-produced in the country: solar water heating (SWH)[20] and solar photovoltaics (SPV). According to Rincón et al. (2006), SWH first appeared in the country back in 1942 mainly for residential properties to heat swimming pools. Today, the industry has developed into a large number of small producers. Although Chinese products have a strong presence in the market, supplying larger manufacturers (Gil-Perez and Hansen, 2020), Mexican based technology production capacity reached 23,000 MW in 2016 (Rodriguez Suárez et al., 2017). Globally, the Mexican SWH market has a leading position in the industrial sector. According to Weiss and Spörk-Dür (2018), Growth in Mexico is particularly strong, with the highest number of solar process heat applications worldwide and together with India, accounting for 41% of the installed solar process heat systems globally (Weiss and Spörk-Dür, 2018: 24). Mexico has a solid local solar industry and the ability to provide affordable system solutions to end-users. Mexico’s SWH industry is also an understudied sector, mainly because it consists of a large number of small producers, making it difficult to gather detailed and updated information. In any case, due to the limitations of this thesis, the technological focus of this study is exclusively

[20] Alternatively known as concentrated solar thermal (CST) is a solar energy technology that uses sunlight to generate heat.

on SPV. Chapter 6 will discuss recommendations for future research, considering every potential gap based on the analytical framework for energy transitions.

As discussed in Chapter 3, Mexican electricity production was fully controlled by the Mexican government. Consequently, until 2013 the energy-mix mainly consisted of fossil fuels, until the energy reform liberalized the electricity market and welcomed private investors producing other sources of energy. The expansion of renewable energy projects like the Solar Power Plant Villanueva is the result of Mexico's first energy auctions that took place in 2016. Before providing contextual detail, it is important to note that the analysis of SPV technology also presents a number of challenges. One of the major limitations is that it is mainly international companies who play a central role in developing SPV industries, as they require larger amounts of financial capital with a greater need for attracting non-domestic investors. As a result, contracts surrounding transnational companies and their developments often have carefully tailored confidentiality clauses that prevent the information from being made publicly accessible. This lack of transparency represents an obstacle to learning from and improving renewable energy projects such as Villanueva. Certain obstacles are inevitable in a transition process; however, by combining frameworks, this chapter develops a more nuanced version of the multi-level perspective (MLP)[21] **by considering weaknesses in a way that can enhance the learning curve.**

The northern part of Mexico is well known for arid regions such as the state of Sonora, most of Baja California and Coahuila. Annual rainfall in these areas is small and temperatures during both summer and winter can be extreme. Temperatures are high due to solar radiation

[21] To understand transitions this research proposes the Multi-Level Perspective (MLP). MLP spans foundational social science dichotomies such as: agencies and structure, stability and change, ideational and material dimensions (Abbott et al. 2004). More information on the theoretical framework can be found in Chapter 2.

throughout the year, making it attractive for solar installation facilities to generate electricity from the sun. The first solar photovoltaic park in the state of Coahuila was built in the desert of Viesca, 60 kilometres away from the city of Torreon. Coahuila has political borders with four Mexican states: Chihuahua, Durango, Zacatecas and Nuevo León, and to the North with Texas in the U.S.A. In 2016, the project was among two others to be awarded to Enel Green Power.[22] In total, the Mexican government awarded Enel Green power three solar energy projects, backed by contracts for energy sales to CFE in the next twenty years (Diaz-Lopez, 2017). The construction of the first facility (Villanueva) started in 2017 and was inaugurated in March 2018 as the largest solar plant on the American continent and in Mexico (Enel Green, 2019). Surprisingly, nine months ahead of schedule, Villanueva was distributing power to the Mexican grid. Currently, it has an installed capacity of 828 MW with 2.5 million panels (Enel Green, 2019).

5.2 Conflict and Mobilization

The main issue surrounding this project is labour conflict over contracting and salary payments to local employees. The operating company is Enel Green Power (EGP), an Italian company, which passed on its execution branch to two subsidiaries created specifically to implement the project. The first is the Spanish outsourced company Prodiel located in Sevilla and the other, Novamper Construcción Mexico S.A. de C.V. who subsequently subcontracted to another Mexican company named Codisa Corp Energy Mexico. In other words, the latter is a company subcontracted by another company that in turn was subcontracted by EGP. The conflict dates back to 2017 when Codisa workers went on strike, stating that they were "victims of an act of

[22] Contracts for Villanueva and Don Jose were awarded in the first auctions, while contracts for Salitrillos in the second, both in 2016.

corruption between international companies" (Martínez, 2018). Blockades and strikes continued one day prior to the day of inauguration, which the Minister of Energy and the governor of the state of Coahuila were planning to attend. Prodiel declared that they had deposited 43 million Mexican pesos (2, 162,152 USD) to Codisa but Codisa claimed that debts had increased to almost 180 million Mexican pesos (9,050,871 USD) (see Table 14) for damages and services[23] (Rodriquez, 2018). Consequently, Codisa and its representatives accused Prodiel of fraud, blackmailing and corruption to a total debt of 9.2 million USD for construction work (Rodriquez, 2018). It was claimed by Codisa's legal representative, Savir Ruiz, that the whole incident was orchestrated by Prodiel to undermine Mexican subcontracted companies. Mr. Ruiz explained that Codisa is a well-established company with more than 20 years' experience in the market, is trustworthy and has an impeccable reputation, and that this was not the first time they had developed a renewable project. However, he did highlight that "there must be a regulatory body that protects Mexican companies, otherwise, only foreigner multinationals will benefit, and our national companies will collapse" (Rodriguez, 2018).

The conflict between Prodiel and Codisa grew into a major legal arbitration dispute when the Spanish company Prodiel started a defamatory media campaign against Codisa. As the evidence shows, the media campaign was launched between March 24 and 25, 2018 when the news was published around the country in the journals Milenio, Excelsior and Heraldo de Saltillo, stating that "Accusations made by Codisa's representatives were absolutely false and unreliable" (Savir Ruiz, 2019). The following table shows the debts claimed by the Mexican company Codisa.

[23] Savir Ruiz, legal representative of Codisa claims that back in April, a tractor was burned and machinery was seized by employees from Prodiel which codisa requested a damage fee to be covered (Rodriguez, 2018; Savir Ruiz, 2019).

Table 9. Liability claimed by Codisa to Prodiel. *Source: Author, data retrieved from Savir Ruiz, (2019).*

Concept of Liability	Required Payment Date	Net price in USD	Net price in MXN pesos (Exchange Rate 19.16)
Burned tractor D8T Caterpillar	Abril 4th, 2017	4,475,363	83,831,965
Stolen Trailer CB 7016	December 6th, 2017	-	49,068
Withholdings	August 22nd, 2017	-	4,434,349
Work carried out: weed removal (batch 1,2,3,4 and 5). Work carried out: soil removal, horizontal roads, perimeter roads. Construction foundation, roads, etc.	August 22nd, 2017	-	86,824,546
Interest charged by Codisa	Instant payment	-	4,861,163
	Total	9,394,629	180,001,093

On March 22nd, 2018, a new wave of protests took place involving approximately 250 workers. They now came from different subcontracted companies which had installed the new infrastructure. Workers complained about irregularities and missing salary payments. For instance, they accused the company of paying only one month of salary when they had worked for 10 months (Ituriaga, 2018). Following this conflict, the inauguration ceremony was postponed by Coahuila's governor as he urged companies to find a solution. As a response, defense lawyers stated that "the energy reform does not bring benefits to the country, it does not create jobs, Mexican companies are exploited and left indebted" (Miranda, 2018:26).

5.3 Barriers and Drivers

To identify the most significant global (macro-level) drivers and barriers, all possible barriers and drivers from the three levels (niche, regime and landscape) had to be identified first[24]. Appendix B shows the Interview Protocol and questions that were asked; the empirical section on influences and pressures, challenges and wider reflections on national strategy and powers, were designed specifically to identify barriers and drivers in the case of the Villanueva Solar Power Plant. In order to follow the theoretical framework (see Chapter 2 and Chapter 3), the findings are divided into the three perspectives for national energy transitions (socio-technical, techno-economic and political). Two main topics were identified per perspective, as follows: environmental and social; cultural and regulatory; financial and technical. The following table shows the barriers by sector structure and drivers according to current policy documents.

Table 10. Barriers and Drivers from Villanueva Solar Plant. *Source: Author's own data.*

Perspectives	Topic	Barriers (Sector structure)		Drivers (according to policy documents)	
Socio-technical	Environmental and Social	Risks associated with environment	A. Risks to health and environment	Improvements in environmental impacts	B. Reduction in GHG emissions

[24] Chapter 2. Methodology explores the concepts of the Multi-level Perspective approach that discusses three analytical levels

			(including endemic flora and fauna)		C. Natural resources conservation (Flora and fauna) D. Production process
	Cultural	Attitude of consumers and producers	E. Lack of public interest and awareness regarding solar energy F. Company culture (unexpected fees	Environmental solutions	G. Positive public opinion about solar energy

			and debts)		
Political	Regulatory	Lack of politics and governance	A. Lack of public policy that is concerned with outsourcing companies to protect workers' interests. B. Low support from the federal government C. Transparency in the informati	Green economy (politics and governance)	E. Policy oriented towards green economy F. Support from research institutes and universities G. Strong support from federal government

			on (vulnerability to corruption). D. Weak job regulation		
Techno-economic	Technical	Drawbacks related to project implementation	A. Lack of experts to implement the project locally B. Lack of data and coordination from other large-scale projects	Innovative transformation into improved products	C. SPV technology development D. Support of Research institutes (Learning by Doing, Using or Interacting).

	Financial	Economic disadvantages	E. High investment and operational costs F. Increased property values of the local community's houses G. High transaction costs	Economic advantages	H. Job creation I. Reduction in energy bills paid by companies

Participant 14 mentioned "We shouldn't allow international companies to come and steal, we have a lot to learn, the park (Villanueva) is the largest in Latin America". For instance, workers compromised by demanding two months' pay instead of the 10 they were owed, fearing that they would not receive any payment at all (participant 16). The table shows technical failures, disruption of large-scale projects and accumulation of high transactional costs as examples of regime tensions or barriers related to the techno-economic perspective, contrary to the drivers which create momentum such as scale economies, price or performance improvements which are a result of support from research institutes or universities (learning by doing-using or interacting).

Regime tensions from a socio-technical perspective can be related to negative cultural discourses such as lack of public interest in climate change, air quality, etc. and externalities such as company culture (unexpected fees or costs). For instance, according to interviewee 18, there were cases of unjustified dismissal where colleagues received only two thousand Mexican pesos (equivalent to 97 USD) for being laid off. Additionally, workers claimed that they were not being paid on time. Even on the day of the inauguration, the company that hired them owed employees and workers more than six months of salary (interviewee 18). By contrast, positive attitudes towards solar energy can attract attention and create cultural enthusiasm and reduction of greenhouse gases (GHG) can increase the socio-political legitimacy of reducing environmental impacts. That being Villanueva's case, out of the ten participants in this research, environmental concerns were not reported as a barrier. Whereas wind energy was viewed in relation to environmental degradation (see Chapter 4), the Villanueva project was seen as benefiting the environment and therefore was a driver (see. Table 10). One participant highlighted that 2,600 hectares were used for the relocation of 147,363 species of plants and 25,000 species of fauna (interviewee 19).

Finally, from the political perspective, once can see the absence of public policy around protecting workers' interests when it comes to outsourcing companies. This can cause a decline in political support for the current administration. Another identified political barrier was the removal of supportive policies and transparency of information, causing a loss of confidence in existing policies and a reorientation towards alternatives. Drivers under this perspective can include policies oriented towards a green economy, according to Geels et al. (2017); advocacy coalitions lobbying for policy changes can support niche innovations such as subsidies and supportive regulations. This illustrates a driver of niche expansion as it revolves around investor confidence in radical innovations such as renewable energy.

Thus, the process during a transition can be characterized as a highly complex set of dynamics. Accordingly, the analytical framework for addressing the second research question brings together two bodies of literature described in the previous chapters, namely, the three perspectives on national energy transitions (Chapter 3) and the multi-level perspective (Chapter 2). As discussed earlier, these areas of study have largely developed as separate fields. The following table summarizes not only barriers and drivers by level but also according to the interactions between the three levels.

Table 11. Barriers and Drivers by Level. Source: Author's own data

Barriers and Drivers by Level			
MLP Level	Socio-technical	Political	Techno-economic
Niche (micro-level)	A, E, C	A, C, F	A, B, E, G
Regime (meso-level)	A, F, C, D	A, B, C, E, F	A, B, C, D, E, F, G, H
Landscape (global)	B, C	A, C, E, G	B, C, D, F, H

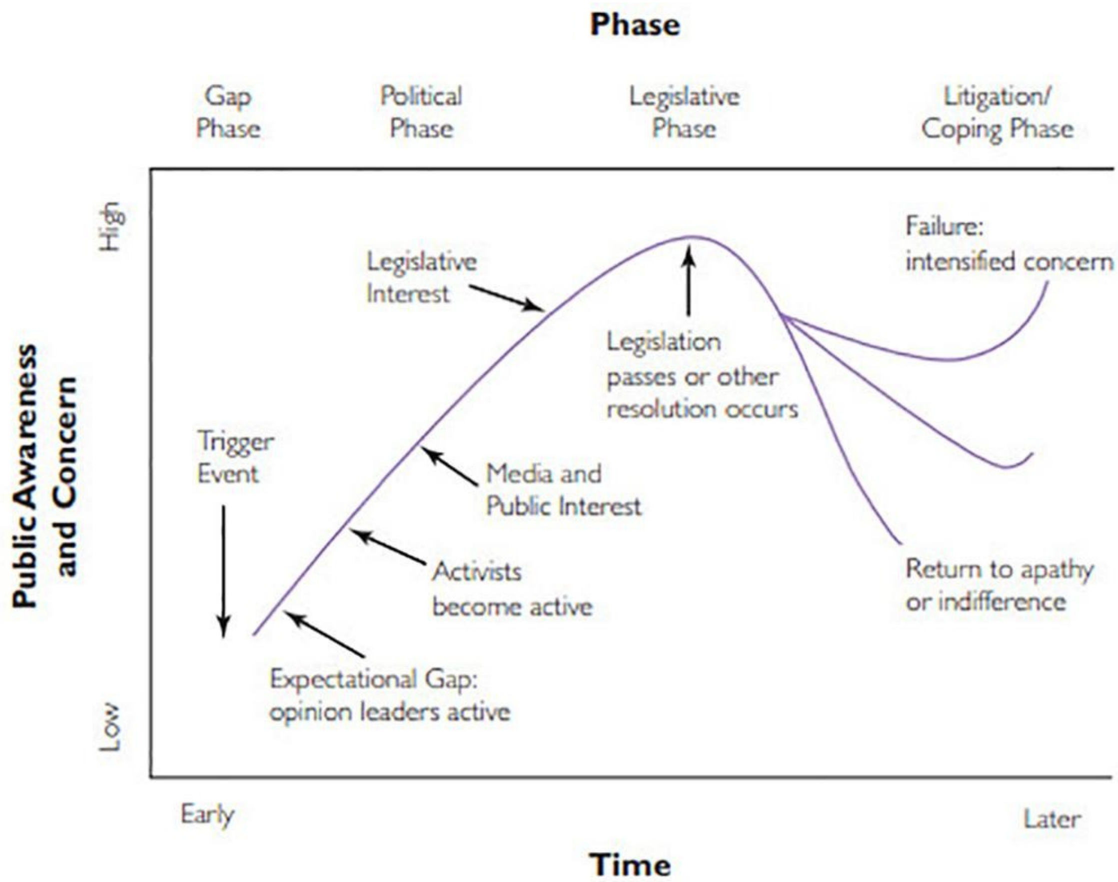
The main learning from Villanueva case study is that transitions are multi-dimensional, long processes and that policy makers cannot rely solely upon a single policy or market instrument, especially when these continue to face major obstacles in society. Geels et al. (2017) argue that policymakers should use instead a range of tools such as regulatory instruments (e.g. laws, performance targets, etc.), financial instruments (taxes, loans, subsidies, grants) and processual instruments for example (public debates, consultations, roadmaps). Rogge and Reichardt (2016) add that this mix of instruments will need to vary between countries and over time, depending on political cultures and stakeholder configuration. Three main points arise from this. Firstly, low-carbon transition is not only about the diffusion of a new development or technology but also about changes in broader political struggles and cultural practices; hence, it is a non-linear process because certain policies can experience setbacks or accelerations. Secondly, a low-carbon transition will require complex negotiations between the different levels within the system, including social acceptance (legitimacy), political feasibility, social security, etc. According to Geels et al. (2017), benefits need to be aligned with other objectives to gain general stakeholder support. Finally, we can learn from this case that a transition does not only involve international firms and authorities to implement a project but also a wider range of actors such as media, civil society, government ministries, local residents, etc (Markad et al., 2012).

5.4 Latest Development

Once the conflict developed between the two companies, the ministry of employment (Secretaria del Trabajo) set up a committee to analyse the problem and explore potential solutions (participant 16). Subcontracted companies demanded that the Ministry of Energy (SENER) intervene, following the auctions for renewable energy projects. In December 2018, a lawsuit was issued against Prodiel and Novamper which did not bring any resolution. According to participant 18, an important testimony by the Union Leader affirmed that Prodiel bribed the authorities so that no penalty would be issued against them (participant 18). However, **proof of the clarification process cannot be found, and the general response is**

under negotiation. The fourth energy auction was supposed to take place in December 2018; however, right after president Andres Manuel Lopez Obrador took office in early December, it was announced that the auction was officially cancelled because the objectives and scope needed to be carefully reviewed (Djunisic, 2019). Figure 11 below represents public awareness and concern with the timings and phases of transition dynamics lifecycles **(Rivioli and Waddock, 2011:91).** According to Rivioli and Waddock (2011), the trigger event that brings an issue onto the table for discussion is often unpaid wages. Accordingly, in the Villanueva case, the main visible conflict was between employee and unpaid workers. However, this trigger event began to raise public awareness and change shareholder expectations, including the companies involved in the conflict (see Figure 11). Activists became active and started to attract support from "mainstream" citizens and organisations, and these voices eventually became too loud to ignore (Ravioli and Waddock, 2011). As forms of mobilizations continued, in the case of Villanueva there were street protests, blockades of facilities and lawsuits. These mobilizations drew the attention of the media which then leads to increased public awareness. Media involvement increases the likelihood that institutional processes will be given priority and institutions forced to listen to the demand for change.

Fig 11. Transition Dynamics Lifecycles. *Source: Ravioli and Waddock 2011:91.*



According to Ravioli and Waddock (2011), with the gain of media attention, issues can be resolved by being institutionalized into regulations or codes of practice (legislative outcome) or by becoming norms and expectations (a social or industry expectation outcome) or they can fall into a public opinion "black hole" to rise again in the future when new problems arise (Ravioli and Waddock, 2011:90).

Figure 12. Mexican Policies and Laws introduced between 2017 and 2020. *Source: Author.*

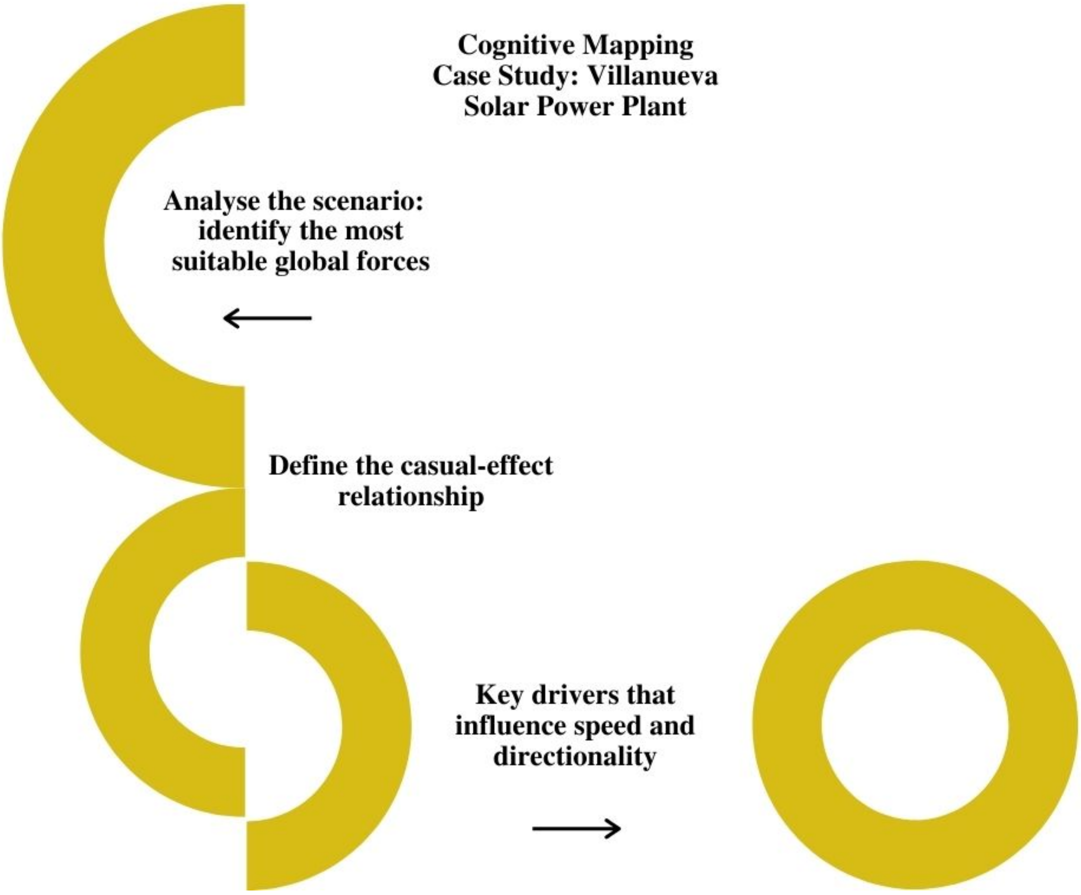
Policy Name (Drivers)	Year
Safety, Continuity and Quality issued for the National Electric System	2020
The National Transition Energy Strategy	2020
Guidelines for transfer stations and operations associated with transport and distribution of hydrocarbons through pipelines	2019
Ownership Tax for Electric Vehicles	2019
Guidelines for environmental protection during design, operation, dismantlement of LNG installations	2018
Guidelines for the prevention and comprehensive control of methane emissions from the hydrocarbons sector (Mexico)	2018
NOM-006-ASEA-2017 Technical criteria for design, operation, dismantlement of crude storage installations, excluding LPG	2018
NOM-021-ENER/SCFI-2017: Energy efficiency and user safety requirements in room air conditioners. Limits, testing and labeling methods	2018
NOM-023-ENER-2018: Energy efficiency in split air conditioners, free discharge and without air ducts. Limits, testing and labeling methods	2018
NOM-027-ENER / SCFI-2018: Thermal performance, gas saving and safety requirements of solar water heaters and solar water heaters with the support of a	2018
NOM-029-ENER-2017: Energy efficiency of external power supplies. Limits, Test Methods, Marking and Labeling	2018
Official Mexican Standard NOM-007-ASEA-2016 Transport of natural gas, ethane, and gas associated with coal by pipeline	2018
Online Diploma Training in Energy Efficiency for Municipalities	2018
Thermal efficiency regulation of solar water heaters (NOM-027-ENER/SCFI-2018)	2018
Energy Efficiency Roadmap	2017
Excellence in Energy Efficiency in Buildings	2017
Fiscal advantage public charging	2017
Guidelines for industrial and operational security, and environmental protection in activities of exploration and extraction of unconventional hydrocarbons	2017
NOM-005-ENER-2016: Energy efficiency of household electric washing machines. Limits, testing methods and labeling	2017
NOM-016-ENER-2016 Energy Efficiency for Electric Motors	2017
NOM-016-ENER-2016: Energy efficiency of AC motors, three-phase, induction, squirrel cage type, nominal power of 0.746 kW to 373 kW. Limits, testing metl	2017
NOM-029-ENER-2017-External Power Supplies	2017
National deployment of free public EVSE	2017
Official Mexican Standard NOM-003-ASEA-2016 Distribution of natural gas and liquid petroleum gas in pipelines	2017
Retrofit Programme of Sustainable Improvement in Existing Housing	2017
Roadmap for Building Energy Codes and Standards for Mexico	2017
Second Regulation of the Energy Transition Law	2017
Voluntary Agreement Programme	2017

An overview of the polices and law trends that were implemented around the time of the conflict provided a helpful context for the analysis. The study findings suggest that there is a casual-effect relationship between the transition dynamics with the groups involved (local governments, regular citizens, industrial workers, etc.). It is clear from this study that to examine low-carbon transitions one not only needs to understand the political context but also the policy context. Thus, the following section presents the cognitive mapping that was developed to provide useful insights for understanding the transition dynamics and frame the case study. This section links the literature and the debates around the three perspectives in energy transitions, to create a stronger combined approach.

5.5 Cognitive Mapping

To facilitate the transition and to unlock its potential, development should be based on a systematic understanding of transition drivers and barriers. As noted, transitions are proceeding at a very different speed and direction in different parts of the country. Within the dynamics of energy transition (i.e. the way in which policies are implemented, modified or discontinued (Gottschamber and Zhang, 2020)), policies represent a critical component. Within this framework and based on the Villanueva case study, cognitive mapping helped with understanding how global forces are influencing transition in Mexico. The cognitive mapping is divided into three stages of a non-linear process: the first stage is the analysis of scenarios to identify the most suitable barriers and drivers. Once the dynamics have been identified, the second stage involves exploring and arriving at a definition of the cause-effect relationship. During this stage, transitions are considered as multi-dimensional and taking place over long periods of time. Figure 13 below illustrates the cognitive reasoning underpinning this section, the aim being to understand the dynamics behind the transition in Mexico.

Figure 13. Cognitive Mapping for Case Study: Villanueva Solar Power Plant. Source: Author.



5.6 Transition Dynamics

In conclusion, Chapter 5 posits that actors can mobilise institutional conditions across multiple levels. In the case of Villanueva, a steering process was led by niche actors through strikes, demands and media response. This can result in the transition moving towards different pathways and directions to a more sustainable future. New projects provide opportunities to collectively shape prospective system structures. For instance, opposition arising from renewable energy developments could be an opportunity to define the problems that need to be addressed by different sets of actors such as policymakers, international companies or governments. The findings in this chapter indicate that protests or activist campaigns may increase public and media attention which subsequently triggers political interest. In the case of Villanueva, for example, energy auctions to be attended by international investors were cancelled and this was followed by an announcement made by the president Amlo on June 17th, 2021 that there would be a public solar power plant built in the state of Sonora with domestic financial capital. In the short-term, ministers or government leaders may react fast by cancelling inauguration ceremonies or other formal events and instead set up meetings to explore different solutions with local stakeholders. If awareness remains high and becomes nationwide, new legislation may follow that directly influences the dynamics of transition (Sovacool et al., 2020). Policy may address the problem in the short term; however, it can also fail. Currently, the Villanueva project is at an early stage of development and more research is needed to learn more from the experience. Further research could apply the analytical framework developed in this case study. Findings and limitations are briefly discussed in the following chapter. The concluding remarks from Chapter 4 and Chapter 5 focus on the key points of the study and implications of the findings.

Chapter 6. Analysis

This section summarizes the results from the analysis of the two cases, applying the analytical framework presented in Chapter 2 and Chapter 3. The case study sites are Wind Farm La Venta (Chapter 4) and Solar Park Villanueva (Chapter 5). These cases are representative of the wider sociotechnical electricity system from production and transmission to supply, as they interact with the national electricity grid and institutions such as the Federal Electricity Commission (CFE), etc. The following section discusses the findings regarding energy transitions.

6.1 Analytical Framework

The central objective of this study was to understand the dynamics behind the electricity system. The findings demonstrate the strategies behind system change or in other words, the conditions within which large-scale social change can occur (Chapter 4 and Chapter 5). For instance, the La Venta case study explored the first wind power plant to be built in the country back in 1994. The case study gave both a historical and a comparative account of alignment patterns between regime and niche actors' expectations, in relation to the emergence of social resistance. By contrast, through the second case study, Villanueva, located in the northern part of Mexico, the analysis highlighted how the barriers and drivers global actors encounter, influence the long-term development of the system. The size and geographical location of Enel Green Power's photovoltaic solar park helped to illustrate how widely shared dynamics can build goals for further actions. In this sense, the research highlights how innovation is shaped by society. By exploring the limitations (Chapter 2), ethical considerations (Chapter 2) and future research (Chapter 6), the study has contributed to understanding the role of social resistance, expectations and macro-forces in altering the speed (barriers and drivers) of sustainable transitions. Altogether, it has provided a general picture of how a transition may move in terms of structural change.

This research has demonstrated through a qualitative lens, the complex interactions between actors and exogenous macro trends as they impact transitions to low carbon energy systems (Chapter 4 and Chapter 5). Pathways of local resistance that can potentially influence changes in the system were identified. The unit of analysis was the country (Mexico), with a focus on two renewable energy developments: La Venta and Villanueva. The two cases comprised subsystem components including location, communities, institutions and organisations, components of the energy system that are embedded in the government, society, technology and subject to global pressures. In other words, this study adopted a collective approach that helped to understanding energy transition in terms of direction and speed. The approach included the analysis of 20 semi-structured interviews (see appendices A and B) and various policy documents related to the cases (see Annex 2). The methods used in the research were described more in depth in Chapter 2. Finally, the two research questions addressed in this study were;

- How does social resistance emerge (what are the main influences/pressures) related to system change?

- How do global forces (landscape-level) influence the speed and directionality of the transition?

6.2 Prior Research and Literature Gap

The expansion of renewable energy in Mexico since 1994 has been explored by scholars in the last 20 years. In earlier research, studies focused on the social impacts of wind energy expansion, particularly in the Isthmus of Tehuantepec. For instance, Huesca-Pérez, Sheinbaum-Prado and Köppel's work engages with the social implications of wind energy whilst maximizing the socio-economic benefits (2016). Likewise, Velasco-Herrejon and Bauwens (2020) use the energy justice framework to analyse the capability dimensions, highlighting the social aspects of the energy transition in Mexico. By interviewing a different range of stakeholders, they show how local-level concerns have resulted in negative perceptions of wind farms. A historical analysis of the main features of wind development in the southern part of Mexico (Avila-Colero, 2017) shows how the neoliberal political agenda has shaped energy projects, leading to local resistance. More recently, Torres Contreras (2018), examines the long-term social effects of renewable energy developments, arguing that the region has yet to benefit from these developments.

Although these studies are insightful, current renewable energy research in Mexico is limited in two ways. Firstly, the studies focus mainly on the southern part of the country without considering other geographical regions. A generalized understanding of renewable energy transitions may be limited as a result. Additionally, while previous studies consider the local expansion of renewable energy, they do not take into account the dynamics of system change. Future research should focus on a larger and more representative picture of renewable energy developments in Mexico.

In general terms, the study of technical change and innovation has focused on its dynamics and characteristics. Academics started looking at technology from the perspective of both social science and economics in order to identify common characteristics of the evolution process of a system. Indeed, Joseph A. Schumpeter was among the first economists to position technological change as a basis for economic growth (Schumpeter, 1911). However, while he saw technology and social organisations as an exogenous factor of the economic process, modern economists have internalised certain social factors, such as climate change, as critical long-term issues for the economic process. Economic energy models did not explicitly include CO2 emissions in their analyses until Nordhaus and Manne (1977) developed global cost-benefit models named Integrated Assessment Model (IAM) or Dynamics of Inertia and Adaptability (DIAM) in energy systems. IAM assumed a cost function which represents a competitive market in equilibrium but does not model government interventions or volatility. IAM focuses on quantitatively exploring complex long-term changes but has difficulty in adequately representing local-level phenomena, technological innovations and realistic behaviour of social actors (Cherp et al., 2018). These stand in contrast to sociotechnical transition studies which involve level dimensions and complex reconfigurations of policy, infrastructure, scientific knowledge, social and cultural practices to sustainable ends (Geels, 2011), an area of study that can be referred to as transformative innovation. Technologies tend to be part of a larger system: these innovations and technical systems have social and political qualities embodied in them. Although independent fields of social science help us to understand sustainable energy transformations, they fail to enable dialogue between the different perspectives.

Research in innovation studies has therefore focused on how systems function and how they undergo far-reaching changes (Van de Bergh et al., 2011). In the late 1990s, a range of studies focusing on transitions initially discussed technological regime transitions or shifts (Kempt et al., 1998; Rip & Kemp, 1998; Schot & Rip, 1996). This was followed by political science and theories of governance becoming more influential (Meadowcroft, 2011; Verbong and Loorbach, 2012), alongside a more substantial strand of transition research in the early 2000s (see for example, Geels, 2002; Elzen et al., 2004; Geels & Schot, 2007 and Rotmans et al., 2001).

Markad et al. (2012) 's methodology typology for studying such transitions towards sustainability was a watershed in the field, as was including transition management I (Kern & Smith, 2008 and Loorbach 2010), the multilevel perspective (MLP) (Geels, 2002; Geels & Schot, 2007; Genus & Coles, 2008; Smith et al., 2010) and technological innovation (Bergek et al., 2008; Jacobsson & Johnson, 2000). TM adopts a process-oriented approach to its examination of how transitions can be managed through strategies for public decision-makers and private actors (Rotmans et al., 2001). The TM approach views transition management as the “deliberate intervention in pursuit of specific goals, like those of sustainability” (Shove & Walker, p.764).

By contrast, MLP looks at different aspects of the system over time, to assess transition dynamics and activities which aim to bring about radical or incremental change (Hodson et al. 2015, p.2). MLP applied to sociotechnical transitions has attracted a fair amount of attention (Geels, 2002; Geels & Schot, 2007; Genus et al., 2008, Smith et al., 2010). This perspective is a middle-range theory and aims to examine the complex dynamics of sociotechnical changes through analytical and heuristic concepts from various works of literature (Geels, 2010). MLP: also seeks to explain non-linear processes that unfold over decades; it involves multiple social groups and technical artefacts; has unclear boundaries in space and time; and leads to uncertain and contingent outcomes (Sorrell, 2018).

This study, by contrast, considered prior research learnings (Chapter 2) and identified a communication gap between the disciplines. Throughout the thesis, the importance of using different sets of knowledge to explain energy transitions has been emphasized. These include the sociology of technology with the integration of science and technology studies (Chapter 3); economics (Chapters 3, 4 and 5); political science (Chapters 2, 3, 4 and 5); and history (Chapters 1, 2, 3, and 5). Findings have demonstrated that the dynamics of energy transitions are complex and that is why the three perspectives on national energy transitions (techno-economic, socio-technical and political) were integrated in the analysis. It was concluded that in order to change transition pathways, energy systems will require major and simultaneous synergic changes in multiple aspects. The research has also demonstrated that energy transition is a multi-layered and multi-actor phenomenon; as such, future research has to consider a system perspective in exploring energy transitions. The following image represents

6.3 Conceptualising Energy Transitions

The research findings have illustrated that transitions have to be driven by policy or innovation, which accordingly shape the pace and direction of change. Evolving to a more sustainable production and consumption model requires speed and directionality within the system. Markets cannot yet provide a strong platform to reduce GHG emissions because they are driven by cost and demand. At the moment, fossil fuels remain the lowest cost option available on the market. At the same time, the cost of both solar and wind energy has dropped significantly over the last few years. In 2017, worldwide energy costs reached 0.03 USD/kWh (IRENA, 2018) and according to José Navarro, Director for Wind Power, wind energy produced in Mexico reached the lowest production cost in the world, making it a much more attractive alternative for investors. The drive for increased profits provides incentives for innovation and thus a sustainable future. On the other hand, it is not a surprise that if private returns are not well aligned with social returns, innovation itself becomes distorted (Stiglitz, 2010). As a result of these market distortions, actors' aligned expectations of renewables are a necessary precondition for a strategic collaboration between the the three system levels (Chapter 4): niche (micro-level), regime (meso-level) and landscape (macro-level) (Geels 2002) .

Throughout this research, energy transitions have thus been conceptualised as a set of changes to the manner in which society uses or produces energy. Empirically, it was demonstrated that transitioning away from our current global energy system is of critical importance, simply because current energy systems are unsustainable . Countries have followed an economic model of long-run growth set within the framework of neoclassical economics by looking at capital accumulation and higher productivity. A major share of the economic growth is based around fossil fuels such as coal, natural gas and crude oil, accounting for a large percentage of energy supply. Fossil fuels are of great importance as they can be burned producing significant amounts of energy per unit mass. These resources are reserve-based, however, which means depletion is a threat and besides the side effects on the environment, these resources will not last forever.

6.4 Transition Dynamics

The rapid implementation of green economy approaches leads to difficult trade-offs between the political imposition of promoting a lower emission economic model and the readiness in terms of legal framework that protects local workers. Social interests and incumbents' resistance to new technologies play a specific role in shaping the speed at which the electricity sector will develop. The evolution of the energy system involves not just the implementation of new infrastructure and technology but also drivers such as policy and regulations that encompass societies' needs and perceptions, creating a sociotechnical transition . Socio-technical transitions represent a transformation that considers both technological and social systems (Hodson et al., 2010). This change enables society to benefit from technological developments. In this scenario, transitions will occur via different possible pathways; however, such transitions require behavioural change and widespread learning within the sector. Whilst a techno-economic perspective focuses on energy flows and markets, a sociotechnical perspective will focus on energy technologies embedded in the sociotechnical system . Mexico's electricity system provides an example in that it has the societal function of providing energy to households and industrial users. This system is linked to and dependent upon multiple social and technical entities at various levels. These include global energy prices, supply, demand and its associated industries; organisations and interest groups that challenge the behaviour and expectations of users and producers; the knowledge and expertise gained over time; the symbolism and cultural norms that are associated with electricity production; and its usage within multiple institutions, bills, policies and regulations associated with the distribution, generation and consumption of the electricity. Different entities and practices then co-evolve and act together to shape the level, pattern and environmental impacts of the system (Sorrell, 2015). Changing from one system to another is environmentally beneficial in terms of lowering GHG emissions but it also has a detrimental impact both on the Mexican economy and politics.

As a result of this learning curve, at a press conference held on June 17th 2021, president Andres Manuel Lopez Obrador announced that the next photovoltaic solar plant to be built in the country will be owned by the local government of Sonora (AMLO, 2021). He explained that the project will be owned by a public company and distributed to the national grid in coordination with the Federal Electricity Commission (CFE). Additionally, he explained that financing will come from the federal bank which will both reduce energy dependence and limit costs. In this way, industry structure will play a major role in energy system change. This can be seen in the electricity infrastructure in Mexico which relies heavily on its generation capacity and the integration of the electricity network. The Mexican energy system has tried to liberalise the structure of its industry but structural barriers such as corruption appear to be a major threat to the development of its energy transition (see Chapter 5).

6.5 Study Limitations

As was discussed in Chapter 2, the limitations of this study can be divided into two categories: those limitations determined by the field and those that are due to the chosen research methods.

In the first category, the study limitations include the timeframe. As was discussed in Chapter 2. energy transitions tend to occur over a large time frame such as 25 years or more. Thus, historical transitions which are finite and have a more precise ending can yield more exact data.

In this sense, one of the study's limitations is that it investigated a sociotechnical mid-transition. For instance, the Villanueva case study is still at an early stage of development and more future research is needed to gain the full learning experience. Historical energy transitions are completed over many decades and clearly this does not apply to the present energy transition, given that it is ongoing and taking place within different and changing technological and social conditions.

Within the second category, a qualitative methodology can be a limitation due to the size and scope of the methods involved. This study for example can be seen as involving too few participants to carry out a thorough cross-checking of the secondary data collected for the analysis. To address this limitation, key informants were selected in relation to their importance in the organisation and relevance to the cases. Follow- up interviews were also conducted within a six-month timeframe for further clarification and discussions with the participants. As explained in Chapter 2, what was lost in keeping the study to a manageable size was gained in terms of quality of information available for examination. Although the interview is still a common instrument in these fields, other methods could be used and future research should consider those. For example, Velasco-Herrejon and Bauwens (2020) drew on 103 semi-structured interviews and a medium-size questionnaire-based survey (N=382) on energy technologies acceptance. It is important to mention that the methodology and research approach were affected by the global health crisis, COVID-19. Although, the pandemic posed serious challenges to the research, particularly to the fieldwork and primary data collection, adaptations were made and a total of 20 semi-structured interviews were conducted via telephone, email and Zoom call (see Appendix A). A number of these interviews were in direct relation to the case study. Additionally, the interviews were useful for mapping, analysing and verifying the reliability of the secondary data that was collected throughout the three years of research. In this sense, even with the abovementioned limitations, the study makes a valuable contribution to the literature on energy transitions and system innovation. This research is relevant in terms of providing a political economic analysis of the energy system structure in Mexico.

6.5 Policy and Legislation

In terms of political strategy, contradictions can be seen between the former and current governments. These contradictions and shifts are the results of transition dynamics (barriers and drivers). While the focus of the previous government was the global environmental target of reducing GHG emissions, the current government has prioritised energy security. This thesis analyses the change in national policy direction by using analytical and heuristic concepts from various literatures, as they relate to the emerge of social resistance to renewables as well as global factors influencing the direction of the transition. As has been alluded to earlier in the research, the rapid and large-scale deployment of renewable investment in the country has represented a major social challenge, raising questions about how benefits are shared and how policymaking is conducted.

As an example of the shift in the political strategy, in 2018, the sixth round of the North American Free Trade Agreement (NAFTA) renegotiation talks on energy security was an opportunity for policy makers to shift their energy strategy to a more protectionist perspective. It was on this occasion that Mexico’s exclusive ownership of its gasoline and natural gas emerged once again as a new topic. Even though Mexico had stipulated national ownership of all its hydrocarbons resources over one-hundred years ago in its 1917 Constitution, under the North America trade agreement, newly stipulated strategic activities in the energy sector were introduced to protect national interests. These included investment, exploration and exploitation being exclusively provided by the Mexican government. As such, there has been a shift in political strategy, influenced by the protectionist agreement negotiations of the current governmental administration (Liñan-Segura, 2019). Between 2006 and 2017, Mexico followed up on its international commitments with a coherent domestic agenda composed of the aggressive promotion of renewable energy, a package of laws to promote a lower emission economic model and the modernization of its electricity infrastructure. Later, from 2018 to date, the centre of the national agenda shifted from the dilemma of "environmental sustainability" to "energy security" as stated in the Official Journal of the Federation published in January 2020 (DOF, 2020). As explored in this research, the changing policy environment in Mexico can be both a challenge and an opportunity for transition dynamics. That is why a better understanding of these dynamics will provide policy makers with better information.

6.6 Personal Motivations for Conducting this Research

Back in 2015, during my graduate course on Climate Change and Energy Policy, I became a user of En-ROADS climate simulator, based on a system dynamic modelling developed by the Business Department of the Massachusetts Institute of Technology (MIT). This model focuses on how changes in the energy, the economy and public policy systems might affect greenhouse gas (GHG) emissions and climate outcomes. It is certainly useful in terms of creating policy to direct national targets in reducing greenhouse gas emissions. The simulator is underpinned by an extensive body of research, consisting of 100 years of energy data, land and climate data, comprising important factors such as energy demand, GDP, population, policy, climate impacts and CO_2 emissions. The simulator's advanced mode allows the user to choose specific policies such as technology subsidies, technical advances and carbon pricing. The chosen scenarios signal the impact on energy demand, production and prices, global warming, greenhouse gas emissions, etc. All assumptions behind the model can be found in the EN-ROADS Simulator Reference Guide (2021). The five main goals for policy making scenarios based on EN-ROADS are the following;

1. Support economic growth.
2. Provide scenarios for both the rich and the poor alike and should not be regressive.
3. Models should minimise non-climate-related impacts on the environment.
4. Scenarios should be technically, economically and politically feasible under reasonable assumptions.
5. Models should provide a reasonable chance of holding global average temperature increases to no more than 2°C by 2100.

Despite its realistic aims and ambitious reach, EN-ROADS does not incorporate complex data such as geopolitical power relations between levels or local level phenomenon. Yet, one observation to emerge from EN-ROADS modelling is that it is not possible to achieve the 2°C target solely through introducing a carbon price or any other market-based principle (2017, Czaika, et al.). In other words, market-based instruments aimed at reducing externalities and incorporating environmental costs alone are not sufficient to reduce CO_2 emissions. These instruments can include carbon taxes, tradable permits or charges and can be useful instruments for the internalisation of climate change effects. Nonetheless, market-based instruments are an interesting policy option and the negative environmental impacts can be compensated through the design of such instruments and the use of generated fiscal revenues.

Based on these assumptions, one of the solutions for limiting GHG emission is through technology that has not yet been invented. In other words, if we want to maintain the same lifestyle, a technical breakthrough in the next decades is desperately needed to control the pollution effects. Throughout the research it has been argued that transition and innovation go hand in hand. Thus, one of my main motivations for conducting this research on energy transitions is to understand the context in which innovation can make a breakthrough. Innovation is at the centre of technology, the economy and the world. For that, technical breakthroughs are required that will expand at a sufficiently fast rate and to a large enough scale to deliver global and national goals.

6.7 Conclusion

In conclusion, the national implementation of renewable energy as radical innovation requires not only private investments and new technological entrants. It requires a fundamental transformation and readiness at the system level. This study demonstrates that alignment of shareholders' expectations between the three levels (niche, regime and landscape) and social resistance and acceptance, influence transition dynamics (barriers and drivers). This means that these phenomena are behind changing social elements such as policies, regulations for users and producers, market rules, social behaviours, etc. That is why in studying the political economy of energy transition in Mexico, this thesis has adopted a multidisciplinary framework Each stage of the research adopted a conceptual framework that encompasses the three perspectives (techno-economic, socio-technical and political) through a multi-level perspective approach (MLP). Methodologically, the research proposed a collective case study: the wind energy region Isthmus of Tehuantepec in the south of Mexico and the photovoltaic power station named Villanueva in the north,

The findings are summarized in four main points:

1. By conceptualising the notion of energy transition, Chapter 2 identified the most relevant literature and methods. It concluded that a well-designed research on energy transition must include an underpinning theory (meta-theoretical framework: three perspectives), a theoretical background (science and technology studies) and a methodological approach (multi-level perspective).

2. Chapter 3 demonstrated that structural barriers and lock-in within the system can slow down the uptake of renewable energy. By using examples from the existing energy system in Mexico, it explained that if system changes are too radical, they can encounter resistance from incumbents, leading to resistance in communities, from economic to social to political.

3. Chapter 4 demonstrated that shaping actors' expectations and building strong alignment of expectations with new entrants would contribute towards changing old pathways and directions of transitions. New technological entrants provide the niche (micro-level) with the opportunities to collectively shape the prospective socio-technical structures of a system.

4. Chapter 5 concludes that across global scales, different sets of actors can mobilise institutional and organisational conditions towards desired directions with the use of media, strikes and public awareness. Different types of transition dynamics can influence change towards desired directions

Glossary

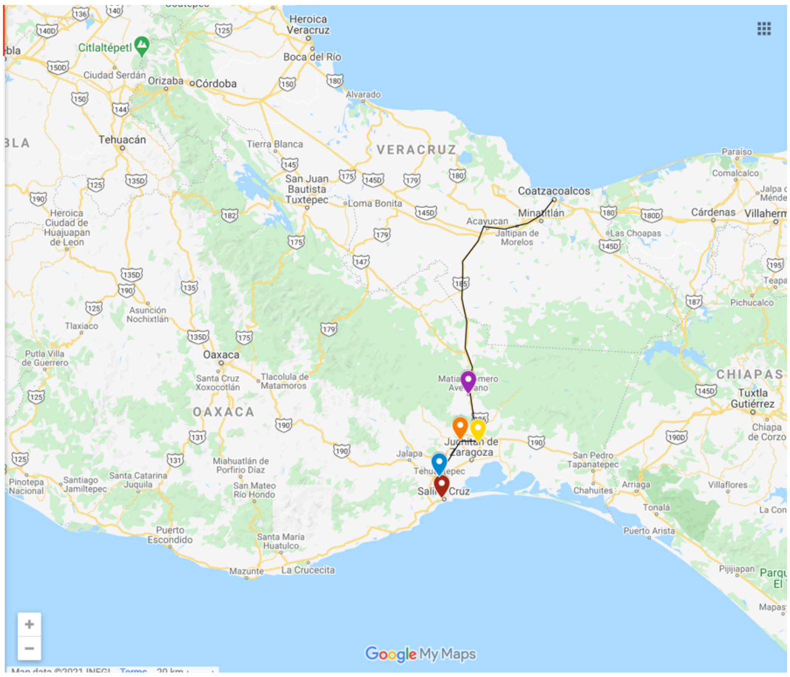
Acceleration	Niches enter the mainstream market and start to compete with the incumbent regime. Increasing diffusion is accompanied by redefinition of rule sets, and thus also of user needs, leading to collective learning processes and eventually, if successful, to new stable rule sets (Schot et al., 2016: 2).
Co-evolution	Focus on the co-construction of the various elements of emergent niches such as actors, technologies, rules and their increasing coherence over time (Schot et al., 2016: 3).
Green Industrial Policy	Government measures aimed to accelerate the structural transformation towards a low carbon, resource-efficient economy in ways that also enable productivity enhancements in the economy (Altenburg and Rodrik, 2017)

Industrial Policy	Government actions to alter the structure of an economy, encouraging resources to move into particular sectors that are perceived as desirable for future development (Altenburg and Rodrik, 2017)
Liberalisation	General freeing from state control
Niche	Protected from direct mainstream market pressures, a niche is a space in which radical solutions that compromise the logic of incumbent regimes are being developed. Compared with regimes, the actors in niches are few, their interrelations sparse, the focal technology immature and the guiding rules in constant flux. An example of a niche is a decentralized system of energy production based on renewables, challenging the dominant regime (Schot et al., 2016: 2).
Privatisation	Selling state-owned assets and entities (potentially competitive, natural monopolies).
Restructuring	Breaking up integrated companies. Vertical or horizontal separation. Accounting, legal or ownership separation.

Socio-technical landscape	Exogenous macro-events and trends (such as wars, migration, urbanization and totality of infra- structures) that shape the dynamics between niches and regimes but are not affected by the latter in the short or mid-term.
Socio-technical regime	A shared, stable and aligned set of rules or routines that guide the behaviour of actors on how to produce, regulate and use energy, transportation, food production or communication technologies. These rules are embedded in the various elements of a socio-technical system (Schot et al., 2016: 2).
Socio-technical system	A configuration of technologies, services and infrastructures, regulations and actors (for example, producers, suppliers, policymakers and users) that fulfils a societal function such as energy provision. These elements are aligned and fine-tuned to each other, forming a system (Schot et al., 2016: 2).
Stabilization	As the niche's actors grow in number, its technol- ogy matures and its guiding rules stabilize, the (now former) niche gradually establishes itself as a new regime. This allows for a sharp increase in adoption as the regime now provides a ready-made

	‘template’ for largely routinized user behaviour (Schot et al., 2016: 2).
Start-up	The internal problems of the regime are intensified by landscape pressure, creating a window of opportunity for novelties that, for the time being, emerge and mature in niches (Schot et al., 2016: 2).
Transitions	Large-scale and long-term (50–100-year) shifts from one socio-technical regime and system to another, involving interactions between landscapes, regimes and niche dynamics (Schot et al., 2016: 2).

Annex 1 Map of the Isthmus of Tehuantepec



Annex 2 Mexican Policies and Laws related to the energy sector between (2012 – 2020)

Policy Name (Drivers)	Year
Safety, Continuity and Quality issued for the National Electric System	2020
The National Transition Energy Strategy	2020
Guidelines for transfer stations and operations associated with transport and distribution of hydrocarbons through pipelines	2019
Ownership Tax for Electric Vehicles	2019
Guidelines for environmental protection during design, operation, dismantlement of LNG installations	2018
Guidelines for the prevention and comprehensive control of methane emissions from the hydrocarbons sector (Mexico)	2018
NOM-006-ASEA-2017 Technical criteria for design, operation, dismantlement of crude storage installations, excluding LPG	2018
NOM-021-ENER/SCFI-2017: Energy efficiency and user safety requirements in room air conditioners. Limits, testing and labeling methods	2018
NOM-023-ENER-2018: Energy efficiency in split air conditioners, free discharge and without air ducts. Limits, testing and labeling methods	2018
NOM-027-ENER / SCFI-2018: Thermal performance, gas saving and safety requirements of solar water heaters and solar water heaters with the support of a	2018
NOM-029-ENER-2017: Energy efficiency of external power supplies. Limits, Test Methods, Marking and Labeling	2018
Official Mexican Standard NOM-007-ASEA-2016 Transport of natural gas, ethane, and gas associated with coal by pipeline	2018
Online Diploma Training in Energy Efficiency for Municipalities	2018
Thermal efficiency regulation of solar water heaters (NOM-027-ENER/SCFI-2018)	2018
Energy Efficiency Roadmap	2017
Excellence in Energy Efficiency in Buildings	2017
Fiscal advantage public charging	2017
Guidelines for industrial and operational security, and environmental protection in activities of exploration and extraction of unconventional hydrocarbons	2017
NOM-005-ENER-2016: Energy efficiency of household electric washing machines. Limits, testing methods and labeling	2017
NOM-016-ENER-2016 Energy Efficiency for Electric Motors	2017
NOM-016-ENER-2016: Energy efficiency of AC motors, three-phase, induction, squirrel cage type, nominal power of 0.746 kW to 373 kW. Limits, testing meth	2017
NOM-029-ENER-2017-External Power Supplies	2017
National deployment of free public EVSE	2017
Official Mexican Standard NOM-003-ASEA-2016 Distribution of natural gas and liquid petroleum gas in pipelines	2017
Retrofit Programme of Sustainable Improvement in Existing Housing	2017
Roadmap for Building Energy Codes and Standards for Mexico	2017
Second Regulation of the Energy Transition Law	2017
Voluntary Agreement Programme	2017
Building Energy Conservation Code	2016
Mexico capacity and power auctions supported by clean energy certificates	2016
Municipal Energy Efficiency Project	2016
NOM-026-ENER-2015: Energy efficiency of inverter air conditioners with variable refrigerant flow. Limits, testing methods and labeling	2016
New Vehicle Tax Exemption for Electric Vehicules - Federal Law for Taxes over New Vehicles	2016
PRESEM - Municipal Energy Efficiency Project	2016
Preferential Tariffs for Charging Electric Vehicles	2016
Regulation on the use of associated gas	2016
Technical guidelines for the use of associated natural gas in exploration and production of hydrocarbons	2016
Energy Transition Law	2015
Guidelines establishing and issuing Clean Energy Certificates	2015
Learning Networks for Energy Management Systems	2015
NOM-002-SEDE / ENER-2014: Safety and energy efficiency requirements for distribution transformers	2015
NOM-006-ENER-2015: Electromechanical energy efficiency in pumping systems for deep well in operation. Limits and testing method	2015
NOM-022-ENER/SCFI-2014: Energy efficiency and user safety requirements for self-contained commercial refrigerators. Limits, testing methods and labeling	2015
National Programme for Energy Management Systems	2015
National program to replace incandescent bulbs with compact fluorescent lamps (CFLs)	2015
Electricity Industry Law (RES grid integration)	2014
Federal Hydrocarbons Law	2014
Geothermal Law	2014
Law for the Agency for Industrial Security and Environmental Protection for the hydrocarbons sector	2014
Mexican Petroleum Law	2014
NOM-001-ENER-2014: Energy efficiency of vertical turbine pumps with vertical electric external motor. Limits and testing method	2014
NOM-004-ENER-2014: Energy efficiency of the motor-pump assembly for pumping clean water for domestic use - 0,180 kW (¼ HP) to 0,750 kW (1 HP) – Limi	2014
NOM-007-ENER-2014: Energy efficiency in lighting systems in non-residential buildings	2014
NOM-009-ENER-2014: Energy efficiency in industrial thermal insulation systems	2014
NOM-032-ENER-2013: Maximum electrical power for equipment and appliances that require standby power. Testing methods and labeling	2014
National Programme for Sustainable Energy Use 2014-2018	2014
Regulation of the General Climate Change Law (Mexico) Regarding the National Registry of Emissions	2014
Special Program for the use of Renewable Energy	2014
Teaching Environmental Responsibility Programme (Chiapas)	2014
Universal Power Service Fund	2014
Constitutional Reform 2013	2013
Energy efficient buildings for low-income households (EcoCasa)	2013
Income tax depreciation for renewable energy equipment expenses	2013
Large-scale renewable energy development project (PERGE)	2013
NOM-013-ENER-2013: Energy efficient lighting systems on roads	2013
NOM-017-ENER/SCFI-2012: Energy efficiency and safety requirements for CFLs. Limits and testing methods	2013
NOM-024-ENER-2012: Thermal and optical characteristics of glass and glazing systems for buildings. Labelling and test methods	2013
NOM-025-ENER-2013: Thermal efficiency of household cooking appliances that use LP gas or natural gas. Limits, testing methods and labeling	2013
NOM-031-ENER-2012: Energy efficiency of light emitting diodes (LED) for roads and public outdoor areas. Specifications and testing methods	2013
NOM-163-SEMARNAT-ENER-SCFI-2013: Emissions of carbon dioxide (CO2) from the exhaust and its equivalence in terms of fuel efficiency, applicable to new	2013
National Climate Change Strategy (Mexico)	2013
National Energy Strategy 2013-2027	ended
National renewable energy inventory	2013
General Law of Climate Change (Mexico)	2012
Light in the House Programme (Oaxaca State)	2012
NOM-015-ENER-2012: Energy efficiency of refrigerators and freezers. Limits, testing methods and labeling	2012
NOM-018-ENER-2011: Thermal insulation for buildings. Characteristics, limits and test methods	2012
NOM-030-ENER-2012: Luminous efficacy of light emitting diodes (LED) integrated lamps for general lighting. Limits and testing methods	2012
National Energy Efficiency Program for Small and Medium Enterprises (SME's)	2012

Source: Author's illustration. Data Source: Secretaria de Gobernación, Diario Oficial de la Federación (DOF).

Appendix A: List of Interviewees

For ethical and confidentiality reasons, the identities of the participants for the present research will remain anonymous. The citation can be found directly throughout the dissertation by using the codes below.

Interviewee Code	Position and Organisation	Interview Date /Type
1	Representative at Ministry of Environment and Natural Resources (SEMARNAT)	Zoom (08/06/20)
2	Researcher A at National Institute of Electricity and Clean Energies (INEEL)	Telephone (11/07/20)
3	Student at Universidad del Istmo Campus Tehuantepec	Telephone (06/08/20)
4	National Representative at the Federal Electricity Commission (CFE)	WhatsApp Call (03/06/20)
5	Project Manager at Ministry of Energy (SENER)	Telephone (24/05/20)
6	Representative at Ministry of Environment and Natural Resources (SEMARNAT)	Zoom (12/08/20)
7	Community Leader in Oaxaca	Telephone (15/03/20)
8	Researcher at the Mexican Electric Research Institute (IIE)	Zoom (21/07/20)

9	Project Manager at Ministry of Social Development (SEDESOL)	WhatsApp Call (01/10/20)
10	Community Leader in Oaxaca	WhatsApp Call (17/11/20)
11	National Representative at Ministry of Innovation, Science and Technology (SICYT)	Telephone (20/04/20)
12	Renewable Energy Developer	WhatsApp Call (14/11/20)
13	Senior Manager at National Institute of Electricity and Clean Energies (INEEL)	WhatsApp Call (14/01/21)
14	Community Leader	Zoom (12/08/20)
15	Student at Universidad Autónoma del Estado de Coahuila	WhatsApp Call (03/03/21)
16	Former Employee	WhatsApp Call (20/04/21)
17	National Representative at National Energy Control Centre (CENACE)	WhatsApp Call (17/04/21)
18	Community Leader	Zoom (12/05/21)
19	Former Employee	Zoom (24/05/21)
20	Renewable Energy Developer (Solar)	Zoom (26/05/21)

Appendix B: Interview Protocol

INTERVIEW QUESTIONS Interviewee Background

Participant (Number) Title and Name: ____

Level (case study/niche, regime, landscape): _________________________________

Empirical

Background

Which region are you from?

Which renewable energy projects are you familiar with?

Are you or any member of your community directly affected by any of these developments?

Expectations and Perceptions

What is your general perception of new renewable energy projects? (Positive, negative)

Do you share the same expectations on renewable energy with that of the government or representatives in your region?

Have your expectations or perceptions on renewable energy developments changed over time?

Influences and Pressures

What were the main influences or pressures surrounding the renewable energy project (such as policies, organisations, institutions)?

How did these influences/pressures operate and shape the development?

Challenges

What were the current key challenges?

How does these key challenges appear?

Do these challenges affect social acceptance to renewable energy technologies?

Wider Reflections

National Strategy

What do you think the national strategy on energy transition should be? (Liberalisation, energy security, environmental)

Do you agree in receiving foreign investment for developing renewable energy technologies?

Do you think Mexico takes a centralised or decentralised approach to energy decision making?

Pressures and Powers

What are the main influences on public energy policy relating to renewable energy development?

What is the relationship between the different powers involved in energy development?

References;

Arnulf G. (1996) Time for a Change: on the Patterns of Diffusion of Innovation. P. 19-42

Atienza, J.C., I. Martín Fierro, O. Infante, J.Valls y J. Domínguez. (2011) Directrices para la evaluación del impacto de los parques eólicos en aves y murciélagos (versión 3.0). *SEO/BirdLife*

Avila-Calero, S. (2017) Contesting Energy Transitions: wind power and conflicts in the Isthmus of Tehuantepec. *Journal of Political Ecology.* Vol. 24. Pp: 993-1012

Aviles-Hernandez and Olinco V. (2008) Proyectos de Energía Eólica En El Marco Del Tratado Puebla Panama; Trasnformación En Las Estructuras Socioculturales: El Caso de La Venta, Oaxaca. *National Autonomous University of Mexico.*

Barrios L. and Rodriguez A. (2004) Behavioural and environmental correlates of soaring-bird mortality at on-shores wind turbines. SEO/BirdLife. *Journal of Applied Ecology*. Issue 41. Pages 42-2008

Bashmakov I. (2007) Three Laws of Energy Transition. *Energy Policy.* Vol. 35 Pages.3583-3594

Batel S., Devine-Wright P., and Tangeland T. (2013) Social Acceptance of Low Carbon Energy and Associated Infrastructures: A critical discussion. *Energy Policy* (58) Pages1-5

Bennett, S.J., (2012) Using past transitions to inform scenarios for the future of renewable raw materials in the UK. *Energy Policy*. Vol. 50 Pages.95–108.

Binford L., (1985) Political Conflict and Land Tenure in the Mexican Isthmus of Tehuantepec. *Source Journal of Latin American Studies.* Vol. 17. Pages 179-200

Bloomberg New Energy Finance (2018) New Energy Outlook 2018. Online. Available at: https://about.bnef.com/new-energy-outlook/#toc-download Accessed on January 25th, 2019

Borja D., Sosa M.., Oscar A. Salgado S., and Fernando M. (2005) Primer Documento Del Proyecto Eoloeléctrico Del Corredor Eólico Del Istmo de Tehuantepec. *México: Instituto de Investigaciones Eléctricas.*

Budde, B., Alkemade, F., and Weber, K.M. (2012) Expectations as a key to understanding actors strategies in the field of fuel cell and hydrogen vehicles. *Technological Forecasting and Social Change*. Vol. 79. Pages 1072-1083

Budde, B. and Konrad K. (2019) Tentative governing of fuel cell innovation in a dynamic network of expectations. Vol. 48. Pages 1098-1112

Bryman, A., (2012) Social research methods . Oxford: Oxford University Press. Edition. 4

Bridge, G., Bouzarovski, S., Bradshaw, M., & Eyre, N. (2013) Geographies of energy transition: Space, place and the low-carbon economy. *Energy Policy*. Vol. 53, Pages. 331–340.

Bridge, G., (2010) Resource geographies 1: Making carbon economies, old and new. *Progress in Human Geography*, Vol. 35(6), Pages.820–834.

Bijker, W.E. & Law, J., (1992) Shaping technology building society: Studies in sociotechnical change, *MIT Press.*

Christensen J.L., and Lundvall, B. (2004) Product innovation, Interactive Learning and Economic Performance. *Emerald Group Publishing Limited*.

Cherp A., Vichenko V., Jewell J., Brutschin E., and Sovacool B. (2018) Integrating techno-economic, socio-technical and political perspectives on national energy transitions: A meta-theoretical framework. *Energy Reserch & Social Science*

Castillo-Jara, (2011) Problemática en torno a la construcción de parques eólicos en el IStmo de Tehuantepec. Online. Available at: https://www.eumed.net/rev/delos/12/ECJ-Parques%20eolicos.pdf

Accessed on January 25th, 2021.

Czaika E. and Selin, E. (2017) Model use in sustainability policy making: An experimental study. *Environmental Modelling and Software*. Pp. 54-62

Davidsson, S., Walan, P., Johansson, K., Höök, M. (2014) Phosphate rock production and depletion: Regional disaggregated modeling and global implications. *Resources, Conservation & Recycling*

Dawson P. and Daniel L. (2010) Understanding social innovation: a provisional framework. *International Journal of Technology Management.* Pages. 1-20

Diaz-Lopez B. Enel breals ground on 754 MW solar park in Mexico. PV Magazine. [Online] Available at: https://www.pv-magazine.com/2017/03/30/enel-breaks-ground-on-754-mw-solar-park-in-mexico/ [Accessed on June 12th, 2020]

Drewitt L., and Langston R., (2008) Collision Effects of wind-power generators and other obstacles on birds. *Royal Society for the Protection of Birds*. Peterborough, United Kingdom. 233-267

Djunisic, S. (2019) AMLO govt cancels Mexico's 4th long-term electricity tender. Renewable Now https://renewablesnow.com/news/amlo-govt-cancels-mexicos-4th-long-term-electricity-tender-641803/

Edomah, Norbert *(2020) Electricity and Energy Transition in Nigeria. Taylor & Francis, 2020.*

Eds. A. Irwin, B. Wynne (Eds.) (1996) Misunderstanding Science? The Public Reconstruction of Science and Technology, *Cambridge University Press*.

EN-ROADS(2021*)*. Simulator Reference Guide. *https://img.climateinteractive.org/wp-content/uploads/2021/01/En-ROADS_Reference_Guide_012221.pdf*

Ellis, G., Cowell, R., Warren, C., Strachan, P., Szarka, J., Hadwin, R., Miner, P., Wolsink, M., Nadai, A. (2009) Wind power: is there a "planning problem"? Expanding wind power: a problem of planning, or of perception? The problems of planning a developer's perspective wind farms: more respectful and open debate needed, not less planning: problem "carrier" or proble. *Planning Theory & Practice*, Vol. 10(4), Pages.521–547.

Elliott, D., Schwartz M., Scott G., Haymes S., Heimiller D., George R., (2003) Wind Energy Resource Atlas of Oaxaca. *Golden*. doi:10.2172/15004364.

Felt, U., Fouché, R., Miller C., and Smith-Doerrr (2017) Handbook of Science and Technology Studies. MIT Press.

Markad J., Farla J., Reven R., and Coenen L., (2012) Sustainability Transitions in the Making: a Closer look at Actors, Strategies and Resources. Vol. 79 Pages. 991-998

Feldman M. (1994) The Geography of Innovation. *Spring Netherlands.* Pages 1-156

Friede, S. (2016) Entinced by the Wind – A Case Study in the Social and Historical Context of Wind Energy Development in Southern Mexico. Pages 1-43

Fudge, S., Peters, M. & Woodman, B., (2015) Local authorities and energy governance in the UK: Negotiating sustainability between the micro and macro policy terrain. *Environmental Innovation and Societal Transitions.*

Geels F.W. (2002) Technological transitions as evolutionary reconfiguration process: a multi-level perspective and a case-study. *Research Policy.* Pp-1257-1274

Geels, F.W. (2007) Typology of Sociotechnical Transition Pathways. *Research Policy*. Pp 399-417

Geels F. W. (2010) Ontologies, socio-technical transition (to sustainability), and the multi-level perspective. *Research Policy*. Pp. 495-510

Geels, F.W. (2011) The Multi-Level Perspective on Sustainability Transitions: Respond to Seven Criticisms. Environmental Innovation and Societal Transitions. Pp. 24-40

Geels F.W. and Turnheim B. (2012) Regime Destabilisation as the Flipside of Energy Transitions: Lessons from the History of the British Coal Industry (1913-1997). *Energy Policy*. Pp. 35-49

Geels, F. W. (2014) Regime Resistance Against Low-carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. *Theory, Culture & Society*. Pp. 24-40

Geels, F.W., Sovacool B. K., Schwanen T., Sorrell S. (2017) The Socio-technical dynamics of Low Carbon Transitions. JOULE. Volume 1, Issue 3. Pp. 463-479

Geels F.W., Schwanen T:, Sorrel S., Jenkins K., and Sovacool B., (2018) Energy Research & Social Science. Vol. 40 Pages 23-35

Geels, F.W. (2019) Socio-technical transitions to Sustainability: a review of criticisms and elaborations of the multi-level perspective. ELSEVIER. Pp. 187-201

Genus, A. & Coles, A.-M., (2008) Rethinking the multi-level perspective of technological transitions. *Research Policy*. Vol. 37(9), Pages.1436–1445.

Gil-Perez A. and Hansen, T. (2020) Technology Characteristics and Catching-up Policies: Solar Energy Technologies in Mexico. *Energy for Sustainable Development.* Vol. 56 Papges. 51-66

Goldthau A. and Sovacool B., (2012) The Uniqueness of the Energy Security, Justice and Governance Problem*. Energy Policy.* Vol. 41. Pages. 232-240

Greenhalgh C. and Rogers M. (2010) Innovation, Intellectual Property, and Economic Growth. Princeton *University Press. London*, United Kingdom.

Grometta J, Haussermann H, Longo G. (2005) Social Innovation and Civil Society in Urban Governance: Strategies for an Inclusive City. *Urban Studies* Vol. 4 Pages. 2007-2021

Grubb, M. (2014) Planetary Economics: The Three Domains of Sustainable Energy Developments: Energy, Climate Change and the three Domains of Sustainable Development. Routledge.

Grubler A., (2012) Energy transitions research insight and cautionary tales. Energy Policy. Pp. 8-16

Gründinger W. (2017) Drivers of Energy Transition – *How Interest Groups Influenced Energy Politics in Germany*. Springer VS. ISBN 978-3-658-17690-7. Pp. 1-595

Hambler C. (2016) Wind farms vs wildlife: The shocking environmental cost of renewable energy. The Spectator [Online] https://www.spectator.co.uk/article/wind-farms-vs-wildlife [Accessed June 20th, 2021]

Horváthová B., Dobbinis M. (2019) Organised Interest in the Energy Sector: A Comparative Study of the Influence of Interest Groups in Czechia and Hungary. COGITATIO. Volume 7, issue 1. Pp. 139-151

Hecht G. (1998) The Radiance of France: Nuclear Power and National Identity after the World War II. *Cambridge MIT Press.* ISBN: 9780262082662 PP. 476

Hess, D. (1997). Science Studies: An Advanced Introduction. New York University Press

Hess D. (2015) Publics as threats? Integrating science and technology studies and social movement studies, *Sci. Cult*. Vol. 24 Pages. 69–82.

Hess D., and Sovacool B., (2020) Sociotechnical matters: Reviewing and integrating Science and Technology studies with Energy Social Science. *Energy Research and Social Science.* Vol. 65 Pages. 1-17

Hiriart Le Bert, G. (1996) Viento y Otras Fuentes Alternas. Conexión.

Hunt G. (2002) Golden Eagles in a perilous landscape: predicting the effects of migration for wind turbine blade-strike mortality. *California Energy Commission*. Pages. 1-72

IEA (2011) Social Acceptance of Wind Energy Projects. The International Energy Agency Implementing Agreement for Co-operation in the Research and Deployment of Wind Energy Systems. *IEA Wind.* Switzerland. Pages:1-34

IEA (2018) International Energy Agency. Countries Mexico. [Online] Available at: https://www.iea.org/countries/Mexico/ [Accessed on March 12th, 2019]

IEA (2018b) International Energy Agency. Statistics Data Browser. Total Final Consumption (TFR) by Source Mexico 1990-2016. [Online]Available at: https://www.iea.org/statistics/?country=MEXICO&year=2016&category=Key%20indicators &indicator=TFCbySource&mode=chart&dataTable=BALANCES [Accessed on March 12th, 2019]

INEGI (2015) Población de Cinco Años y Más Hablante de Lengua Indígena. [Online Available] at https://www.inegi.org.mx/temas/lengua/ [Accessed on April 16th, 2019]

IPCC (2014) Climate Change 2014 Mitigation of Climate Change: Working Groups III contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. New York. 1-1419

IRENA (2020) Plantea IRENA Cómo Crecer Energía Renovable en México. https://www.energiaadebate.com/energia-limpia/plantea-irena-como-crecer-energia-renovable-en-mexico/

IRENA (2018) Renewable Power Generation Costs in 2017. https://irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_2017_Power_Costs_2018.pdf

Iturriaga, R. (2018) Cancelan Inauguración de Parque Solar Villanueva en Viesca. *El Siglo de Torreón.* [Online Available] at: https://www.elsiglodetorreon.com.mx/noticia/1443707.cancelan-inauguracion-de-parque-solar-villanueva-en-viesca.html [Accessed on March 12th, 2019]

Jensen M., Johnson B., Lorenz E., Lundvall B. (2007) Forms of Knowledge and Modes of Innovation. *Policy Research.* Vol 36 (5) Pages. 680-693

Juarez-Hernandez S. and Leon G. (2014) Energía eólica en el istmo de Tehuantepec: desarrollo, actores y oposición social. Revista UNAM. Vol.45 Pages. 139-162

Joskow P.L. (2008) Lessons Leaned From Electricity Market Liberalization. *The Energy Journal.* Special Issue. Pages. 9-42

Mikkelsen C. and Stidsen S. (2015) The Indigenous World 2015. International Work Group for Indigenous Affairs. Copenhagen, Denmark Pp. 1-570and Employee Intrinsic Motivation. *International Public Management Journal*. Pages 183-204

Phills J., Deiglmeier K. & Miller T. (2008) "Rediscovering Social Innovation" Sanford Social Innovation Review, vol. 6 Pages. 34-43

Patterson W., (2007) Keeping The Lights On Towards Sustainable Electricity. Edition 1. Routledge. Pages. 1-170

Pozas U. and Martínez I. (2015) Las Multinacionales en el Siglo XXI: Impactos Multiples – El caso de Iberdrola en Mexico y en Brasil. *Editorial 2015 y más*. ISBN: 978-84-940147-4-1 Pp. 1-193

Oaxaca Gob (2020) Energía Eólic. Secretaria del Medio Ambiente, Energías y Desarrollo Sustentable. [Online] https://www.oaxaca.gob.mx/semaedeso/energia-eolica/ [Accessed June 25th, 2021]

Kuzemko , C., Lockwood, M., Mitchell, C., Hoggett, T. (2016) Governing for sustainable energy system change: politics, contexts and contingency. Energy Research & Social Science. Pp. 96-105

Kingsley, P. How to be Danish? A journey to the cultural heart of Denmarl (2012). Atria Books, Marble Arch Press. Pp. 1-192

DOF (2020) National Energy Transition Strategy. *Diario Oficial de La Federación.* Cámara de Diputados del H. Congreso de la Unión *http://dof.gob.mx/nota_detalle.php?codigo=5585823&fecha=07/02/2020&print=true*

DOF (2021) Ley de La Industria Eléctrica. *Diario Oficial de La Federación*. Cámara de Diputados del H. Congreso de la Unión http://www.diputados.gob.mx/LeyesBiblio/pdf/LIElec_061120.pdf

Longhurst N., Chilvers J., (2019) Mapping diverse visions of energy transitions: co-producing sociotechnical imaginaries, *Sustain. Sci*. Pages.1–18.

MacKenzie D & Wajcman J (1999) Shaping Technology/Building Society: Studie in Sociotechnical Change, The MIT Press, Cambridge MA.

Martínez C. (2018) Cancelan inaguración de parquet solar tras protestas de trabajadores en Viesca. *La Vanguardia*. Online Access https://vanguardia.com.mx/articulo/cancelan-inauguracion-de-parque-solar-tras-protestas-de-trabajadores-en-viesca

Markard J., (2006) Innovation Process in Large Technical Systems: Market Liberalization as a Driver for Radical Change. *Research Policy.* Vol. 35. Pages.609-625

Mendoza E., Rivas-Tovar L., Fernandéz-Echeverría E., Fernández-Lambert G. (2020) Social impact of wind energy in the Isthmus of Tehuantepec, Mexico, using Likert-fuzzy. Energy Strategy Reviews. Volume 32.

Merton R. (1973) The Sociology of Science: Theoretical and Empirical Investigations, University of Chicago Press.

Miranda J.C. (2018) Firma Mexicana Acusa Fraude en la Construcción de Parque Solar. La Jornada. https://www.jornada.com.mx/2018/03/22/economia/026n1eco

Navarro, J. (2019) La energía eólica en México es la más barata del mundo. Revísta Energética XXI, Enero- Febrero 2019. Página 70-71.
file:///Users/karengabrielalinansegura/Downloads/441gBt8LWr11kBbIrJfzBkjERknIniRgaHBb10nMpcBPdcYJm59ndhr.pdf

Naumann, M. and David R. (2020) Conceptualizing Rural Energy Transitions: Energizing Rural Studies, Ruralizing Energy Research. *Journal of Rural Studies Vol.* 73 Pages. 97–104.

Nicholls A., Simon J., and Gabirel M.,.(2015) Introduction: Dimensions of Social Innovation. *New Frontier in Social Innovation Research*. Pages. 1-26

Nordhaus, W. (1977) Economic Growth and Climate: The Carbon Dioxide Problem. The American Economic Review. Vol. 67 (1). Pages 341-346

Oudshoorn N, & Pinch T. (2003) The Co-Construction of Users and Technologies, MIT Press, Cambridge MA

Press Conference (2019) La energía renovable no es la solución, pero no estamos en su contra dice CFE. Expansión. https://expansion.mx/empresas/2019/03/28/la-energia-renovable-no-es-la-solucion-pero-no-estamos-en-su-contra-dice-cfe

Ravioli P. and Waddock S. (2011) First They Ignore You: The Time-Context Dynamic and Corporate Responsibility. *California Management Review*. Vol. 53 Pages. 87-105

Rennings K. (1998). Towards a Theory and Policy of Eco-Innovation-Neoclassical and Co-evolutionary Perspectives. *Centre for European Economic Research.* Pages. 98-24.

Rincón M., and Pereyra A.,(2006) Treinta años de Energía Solar en México. XXX Aniversario de la Asociación Nacional de Energía Solar. Pages 1-10

Rip, A. and Kemp, R (1998) Technological Change, Human Choice and Climate Change. Human Choice and Climate Change. Columbus Oxford. Pages. 327-392

Rodriguez F. (2018) Codisa Corp Energy de México asegura que empresa que la subcontrató no le ha pagado y acusa de corrupción; este jueves inaguran el complejo. *La Vanguardia*. Online Access https://vanguardia.com.mx/articulo/protesta-proveedor-de-mega-parque-solar-de-viesca-denuncia-adeudos-de-10-mdd1

Rogge K. and Reichardt K., (2016) Policy mixes for sustainability transitions: an extended concept and framework for analysis. Vol 45. Pages 1620-1635

Savir Ruiz A. (2019) Comunicado Aclaratorio de Codisa Corp Energy a Las Declaraciones Realizadas Por Prodiel México. CIAR GLOBAL https://ciarglobal.com/comunicado-aclaratorio-de-codisa-corp-energy-a-las-declaraciones-realizadas-por-prodiel-mexico/

Saviotti P. (1996) Technological Evolution,Viriety and the Economy. *E.Elgar.* Pp.1- 223

Secretaría de Energía SENER (2017a) Generación Eléctrica Con Energías Limpias. Access Online: https://www.gob.mx/sener/prensa/mexico-cumplira-con-su-meta-del-35-de-generacion-electrica-con-energias-limpias-en-2024-consejo-consultivo-para-la-transicion-energetica [Accessed on June 12th, 2019]

Secretaría de Energía SENER (2017b) Balance Nacional de Energía 2016. Mexico City https://www.gob.mx/cms/uploads/attachment/file/288692/Balance_Nacional_de_Energ_a_2016__2_.pdf Pages 1-136 [Accessed on March 12th, 2019]

Secretaría de Energía SENER (2020) Acuerdo por el que la Secretaría de Energía aprueba y publica la actualización de la Estrategia de Transición para Promover el Uso de Tecnologías y Combustibles más Limpios, en términos de la Ley de Transición Energética. Diario Oficial de la Federación.

Schot J. and Geels F.W. (2008) Strategic Niche Management and Sustainable Innovation Journeys: Theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management.* Vol. 20. Pages 537-554

Schot J., Kanger L. and Verbong G. (2016) The roles of users in shaping transitions to newly energy systems. *Nature Energy.* Macmillan Publisher Limited. Vol 1. Pp. 1-7

Schot J. and Rip A. (1996) The past and the future of consecutive technology assessment. *Technological Forecasting and Social Change*. Pages. 251-268

Shen X. and Lyu S. (2019) Wind Power pevelopment, government regulation structure, and vested interest groups: Analysis based on panel data of Province of China. Energy Policy. Volume 128. Pp. 487-494

Sitton (2014) Informe Final Para El Consejo Oaxaqueño de Ciencia y Tecnología Del Conacyt. Centro de Investigaciones y Estudios Superiores en Antropología Social Unidad Pacifico Sur. CIESAS. Pages 1-120

Smith A. & Raven R. (2012) What is a protective Space? Reconsidering niches in transitions to sustainability. *Research Policy.* Volume 41. Pp. 1025-1036

Smith A., Vob J.P., and Grin J., (2010) Innovation Studies and Sustainability Transitions: the allure of the multi-level perspective and its challenges. *Research Policy.* Vol. 39 Pages. 435-448

Sovacool B. K., Pushkala L. Ratan, (2012) Conceptualizing the Acceptance of Wind and Solar Electricity. Renewable and Sustainable Energy Reviews. Vol. 16 Pages. 5268-5279

Sorrell S. (2018) Explaining Sociotechnical Transitions: A critical Realist Perspective. *Research Policy.* Pages. 1267-1282

Soovacool K. and Hess J. (2020) Sociotechnical matters: Reviewing and integrating science and technology studies with energy social science. *Energy Research & Social Science.* Elsevier Vol 65.

Sovacool B., Hess D., Amir S., Geels F., Hirsh R., Rodriguez L., Miller C., Alvial C., Phadke R., Ryghauh M., Schot J., Silvast A., Stephens J., Stirling A., Turnheim B., Vand der Vleuten E., Lente H., and Yearley S., (2020) Sociotechnical Agendas: Reviewing future directions for energy and climate research. *Energy Research & Social Science*. Vol 70. Pages 1-35 Rodriguez

Suárez R. Espinoza N. Rosenbuch J., Ortega N., Fernández M. Villavicencio K. Armenta M. (2017) La Industria Solar Fotovoltaica y Fototérmica en México. Available Online: https://www.gob.mx/cms/uploads/attachment/file/428621/La_industria_solar_fv_y_ft_en_M_xico-compressed.pdf Accessed on June 20th, 2021.

Stake R.E. (1995) The Art of Case Study Research. *SAGE Publications*. Pages. 1-175

Tobey, R.C. (1996) Technology as Freedom: The New Deal and the Electrical Modernization of the American Home. University of California Press. ISBSN 0-52-20421-2. Pages. 1-311

Torres Contreras G. (2018) Two Decades Under Windmills in La Venta, Mexico. From an Annoyance to a Blessing for some. United Nations Research Institute for Social Development.

https://www.unrisd.org/80256B42004CCC77/(httpInfoFiles)/8CA56CF0E3D06FC9C125833C005AE88F/$file/Overcoming%20Inequalities%204b_Torres%20Contreras---Final.pdf

Torres-Contreras, G. (2020) The Politics of Wind Energy in The Isthmus of Tehuantepec: Wind, Land, and Social Difference. *Institute of Development Studies*. Pp. 1-213

Tovar R. abd Saldivar-Urquiza G. (2007) Central Eoloeléctrica La Venta 2. Revista UNAM Universitaria. Vol. 8, No. 12. ISSN:1607-6779

Truffer B., VoB J.P., and Konrad K. (2008). Mapping Expectations for System Transformations: Lessons from Sustainability Foresight in German utility Sectors.

Unruh G., (2000) Understanding Carbon Lock-in. *Energy Policy*. Vol. 28. Pages 817-830.

Van Driel H., and Schot J.,(2005) Radical Innovation as a Multilevel Process: Introducing Floating Grain Elevators in the Port of Rotterdam. Technology and Culture. Vol 46. Pages.51-76

Velasco-Herrejon and Bauwens (2020) Energy Justice from the bottom up: A capability approach to community acceptance of wind energy in Mexico. Energy Research and Social Science. Elsevier. Volume 70

Wallerstein I. (1974) The Modern World-System I: Capitalist Agriculture and the Origins of the European World-Economy in the Sixteenth Century. *Academic Press New York.*

Wacjman J.,(1991) Feminism Confronts Technology, Penn State Press, University Park, USA

Weiss W. and Spörk-Dür M., (2018) Solar Heat Worldwide. Solar Heating and Cooling Programme, International Energy Agency. Pp. 1-94 http://www.indiaenvironmentportal.org.in/files/file/Solar-Heat-Worldwide-2018.pdf

WISE Project (2014). Create Acceptance: Factors influencing the societal acceptance of new technologies: Meta-analysis of recent European projects. *European Commission*.

Woollacott J. (2020) A bridge too far? The role of natural gas electricity generation in US climate policy. Energy Policy. ELSEVIER. Volume 147.

Wüstenhagen R. (2007) Social Acceptance of Renewable Energy Innovation: An introduction to the Concept. *Energy Policy.* Institute for Economy and the Environment. University of St. Gallen.

Yang K., Petrova Hiteva R., and Schot J. (2020) Expectation dynamics and niche acceleration in China's wind and Solar Power Development. *Environmental Innovation and Societal Transitions.* Pages 117-196

Zárate-Toledo E., Fraga-Berdugo J., Patiño R., (2019) Justice, Social exclusión and indigenous opposition: A case Study of Wind Energy Development on the Isthmus of Tehuantepec Mexico. *Eenrgy Research and Social Science.* Vol. 54. Pages:1-11