The role of technological complexity for sustainable transition policies

The case of solar energy technologies in Mexico

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Abbreviations

ANES	National Association for Solar energy
BMUB	Federal Ministry of the Environment, Nature Conservation, and Nuclear Safety
CFE	Federal Commission for Electricity
CINVESTAV	Center for Research and Advanced Studies
COFER	Council for the Promotion of Renewable Energies in Mexico
CONACYT	National Council for Science and Technology
CONAE	National Commission for Energy Savings
CONAVI	National Commission for Housing
CONUEE	National Commission for the Efficient Energy Use
CRE	Energy Regulation Commission
EDOMEX	State of Mexico (subnational entity)
GEF	Global Environment Facility
GIZ	German Corporation for International Cooperation
INFONAVIT	Institute of the National Housing Fund for Workers
KFW	German Development Bank
LAERFTE	Law for the Use of Renewable Energies and the Energy Transition Finance
LASE	Law for the Sustainable Use of Energy
LTE	Law for the Energy Transition
PEFRHME	Strategic Program for Human Resource Formation in Relation to Energy
PROCALSOL	Program for the Promotion of Solar Heaters
PROSOLAR	Program for the Promotion of Photovoltaic Systems
PV	Photovoltaic
SENER	Mexican Energy Ministry
SEP	Public Education Ministry
SME	Small and Medium Enterprise
SWH	Solar Water Heater
UNDP	United Nations Development Program
UNEP	United Nation Environment Program

Abstract

This thesis research analyzed policies that promote resource mobilization for the development of the Solar Water Heaters and Photovoltaic industries in Mexico. The main inquiry is to identify the role that technological complexity plays in promoting resource mobilization for sustainable transition policies. It is assumed that if the technology is complex, resources are obtained from extra-regional sources, while for simple technologies, resource can be developed locally. The results suggest that the types of policy approaches depend on the stage of the industry and on the resource promoted. The main implications are that policy must place emphasis in the local arrangements to handle extra-regional resources.

1. INTRODUCTION

The effects of climate change are already taking place and are challenging society to act to minimize and adapt to them. Sustainable transitions are one of the most common responses to transform current unsustainable systems and reduce their impact. The energy sector plays a key role in this regard, due to the possibilities of reducing emissions through the implementation of renewable energies. Among others, transitions towards the use of solar energy are taking place all over the world. The process to harness the energy of the sun can be done in several forms; this thesis is going to focus on two technologies. The first one uses the heat contained in solar energy to heat water through Solar Water Heaters (SWH), the heated water can be used for different procedures, the most typical is the direct use of the heated water for housing appliances (e.g. shower). The second technology transforms solar energy into electrical power, through photovoltaic (PV) panels, this energy can be used for any process that requires power. One of the most typical uses of these technologies is in the housing sector.

Several countries around the world are introducing solar technologies to produce heated water and electricity as part of sustainable transitions strategies. Literature has shown that to introduce, develop or form a new industry in a country, four resources need to be mobilized: knowledge, finance, market and legitimacy (Binz, Truffer, & Coenen, 2016). These resources derived from the alignment processes between institutions and technologies and from the systemic relations of structural components of a system. Policies are one of the most common enablers of resource formation processes. The characteristic of these processes varies considerably depending on the technology introduced. In some cases, the technology can be derived, through local innovation processes, from similar technologies that already exist in a region, one of these processes is known as regional branching and considers the combination of local knowledge with another type of knowledge for the development of new industries. In other cases, the technology or knowledge can be imported from outside of the region (extra-regional resources) through the implementation of catching-up policies, which are specific measures design to catch-up new technologies from abroad (Binz, Gosens, Hansen, & Hansen, 2017). Moreover, even mixed processes can take place in which some characteristics of the technology are developed locally, and others are brought from outside.

SWH and PV systems have a lot of similarities, both are standardized mass-produced products, the acquisition process of both technologies is similar, people buy them at a retailer shop and then a qualified installer bring the equipment to the installation site and installs it, the finance mechanisms to get them (credit or loans) are also similar. However, they have a major difference, PV systems are much more technologically complex, its production and installation require more technical capacities.

SWH is a simple technology that uses the heat transferred by the sun to heat water. Otherwise, PV systems are electronic devices that transform the photon energy of the sun into electrical power. This process is more complex than heating water and requires highly trained professionals and technicians, and more investment for design, production, regulation, and installation of this kind of devices.

In the recent years, scholars have proposed frameworks to gain a better understanding of technologies and to be able to propose better policy mixes for its promotion. Huenteler et al. (2016) developed a framework based on analyzing two characteristics: i) the complexity of product architecture, which analyzes the complexity of the product by itself and ii) the scale of production process, which asses the complexity of the process to produce it. The analysis results in the characterization of the technology into either a complex product that is designed and produced considering specific characteristics and specific customers, or a mass-produced product that is marketed wholesale for any customer anywhere.

It is the aim of this thesis to contribute to this line of research by considering the insights developed by Huenteler et al. (2016), but developing a different approach. It is being argued that the framework can be more detailed and technologically specific and can be adapted to analyze and compare technologies with same production process scales (mass-produced items) but different degree of complexity of product architecture like SWH and PV. The thesis analyses policy mixes applied in Mexico to promote the development of the SWH and the PV industries for the housing sector, by identifying how and from where are the characteristic resources of early industrial development processes (knowledge, finance, market, and legitimacy) mobilized and the crucial role of the similarities and differences of the technologies (SWH and PV) in the design of the policies.

There is a common understanding that emerging economies rely heavily on extra-regional resources for new path development processes and specially for sustainable transitions (U. E. Hansen & Nygaard, 2013), due to their mixture of well and ill-functioning institutions (Ramos-Mejía, Nica, Franco-Garcia, & Jauregui-Becker, 2016). That is why, there is a need to understand how these processes works. The empirical case of the development of the SWH and PV industries for the Mexican housing sector can help to gain a better understanding of transitions in emerging economies because it has shown a mixture of local innovation processes with important insights from extra-regional resources, which entails a unique environment for the analysis of the development of the industries in question and could answer important questions about sustainable transitions in emerging contexts.

1.1. Aim of study and research question

The aim of this research is to analyze the policy mixes that promotes the development of two industries in a regional and sector-specific context to identify how resource obtention is promoted, the key question is to answer if resource obtention is promoted through local innovation processes like regional branching or through catching-up policies that promote resources mobilization from extra-regional sources. The hypothesis behind is that the characteristics of the technology and specifically the complexity of the product architecture is the main element that defines how resource obtention is promoted, if locally or extra-regional.

With the aim to make this analysis possible, the empirical case of Mexico will be considered, which started the promotion of SWH and PV industry for the housing sector since the 1980's until present days, showing an interesting mixture of policies that promote the obtention and development of key resources from local and extra-regional sources. Furthermore, the characteristic development of both industries in an emerging economy context like Mexico could help to better understand transitions in nondeveloped contexts. Considering what described above, this thesis project is going to answer the next questions:

- What kind of policies promote the obtention of resources for the development of SWH and PV industries for the housing sector in Mexico, either through regional branching or catching-up processes?
- Do the characteristics of the technology play a role in the policy approach to promote resource obtention, considering the regional branching and catching-up processes identified previously?

1.2. Case study

The study case selected to analyze how policies promote resource obtention is Mexico. It is considered a perfect case because the development of the SWH and the PV sectors started in the last decades, specifically around the 1980's and, since then, both sectors have been growing at similar paces.

The first SWH's appeared in the country since the 1940's, however real efforts to develop it as an industrial sector took place around the 1980's, the first companies, research centers, and NGO's also appeared around these days. Afterward, several initiatives took place that promoted the development of the sector, during this period the collaboration with international cooperation entities was very important for its successful development.

On the other hand, PV sector has not such a long history like SWH, it was introduced to the country since the 1980's and due to the important manufacturing background of Mexico in electronic devices, it was easily introduced. The development of the PV sector as an industry itself took some more time, especially due to the regulatory framework that hindered the installation of private PV systems for power generation. After some reforms to the regulatory framework, the sector started to grow following a similar path as the SWH sector.

One of the main reason that makes this case good for the analysis is that SWH's and PV systems were introduced to the country through the housing sector, which makes the analysis interesting due to the similar characteristics of the market that is being developed for both technologies. That is the reason why the policies that promote both sectors are similar and are promoted by the same governmental institutions: On top of that, the extra-regional organization that has been involved in the promotion of both sectors are the same and the introduction took place in the same time frame.

In addition to this, the characteristics of the technology make also the analysis interesting, due to the similarities and differences between both sectors. SWH and PV systems are a mass-produced product that requires similar market configurations. However, the technology itself its totally different and comes from different backgrounds. SWH is a thermal technology that harnesses the heat of the sun, while PV is an electronic technology that uses the photon energy of the sun and transforms it into electricity. This difference plays a major role because the technical capacities and infrastructure required to produce PV system are higher than for SWH. Furthermore, the regulatory framework is much more complex for electricity producing artifacts than for others.

1.3. Thesis structure

The thesis is divided into seven chapters. The second chapter, which follows from the introduction describes the theoretical background considered for the analysis. Chapter three describes the methodological approach for the research inquiry. Chapter four describes the case to be studied, chapter five describe and analyzes the development of the policies of both sectors in a historical timeline: Meanwhile, chapter six discusses how the obtention of the key resources was promoted. Finally, chapter seven elaborates on the main conclusions and describes the importance of them for sustainable transitions theory in emerging economies.

2. THEORETICAL CONSIDERATIONS

This thesis analyses how policy promotes a solar energy sustainable transition in Mexico. A sustainable transition consider the transformation of a socio-technical system into a more sustainable one (Geels, 2004; Markard, Raven, & Truffer, 2012). Such a transformation can be done in several forms; however, this project only considers two research lines and the linkages of these two with the characteristics of the technology being studied.

The two research lines are: catching-up policies and regional branching processes. This section will describe how the analysis of the policies that promote the solar energy sustainable transition for the housing sector in Mexico is related to these research lines.

The first subsection (2.1) describes the general theory of sustainable transitions emphasizing the early stage of industrial development and the typical resources promoted by the policies during this phase (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008; Binz et al., 2016; Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007). Afterward, a description about two theoretical approaches to develop these resources is given. The thesis aims to answer what kinds of policies promote resource development and which of these approaches are most used by them.

The second subsection (2.2) describes the theoretical considerations about the characteristics of the technology, and the key similarities and differences between SWH and PV technologies. These will help to answer the question about the typical approaches promoted by policy for resource development. It is expected that this research will provide interesting and useful insights towards a better understanding of sustainable transitions in an emerging context like Mexico.

2.1. Sustainable Transitions

The promotion of solar energy requires modifying the way energy is handled by both the demand and the supply side. Academia has developed theoretical models to analyze and understand how this kind of transformations takes place, one of the currently most analyzed models is known as sustainable transitions (Markard et al., 2012). The sustainable transitions framework considers the transformation of a socio-technical system towards a more sustainable one. The concept of socio-technical system derives from innovations studies (Geels, 2004) and is defined as a network of actors, institutions, material artifacts, and knowledge that interact to provide a specific service to society (Markard et al., 2012). Having this in mind, this thesis is dealing with the socio-technical regime of energy supply and with a sustainable transition from a conventional energy source (e.g. fossil fuel) towards a low emission – more sustainable – technology, like solar energy.

The question of how socio-technical systems transform, and transitions takes place have been a critical line of study over the past two decades. A variety of theoretical frameworks to understand these transformations have been developed, one of them is known as Technological Innovation System (TIS). TIS concept was developed in the intersection between evolutionary economics and innovation studies (Binz et al., 2016) , it was first introduced by Carlsson et al. and defined "*as a network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure or set of infrastructures and involved in the generation, diffusion, and utilization of technology*" (1991, p. 111). It analyses relations between the emergence of new technologies and the changes in the institutional and organizational arrangements that occur along these technological innovations (Markard et al., 2012).

Recently, TIS has place attention in the alignment processes of three structural components, from where new paths emerge, these are actors, networks, and institutions (Bergek et al., 2008; Hekkert et al., 2007). Actors are conceived as companies, universities, users, government entities and intermediaries; networks consider alliances, working groups, chambers, and organizations; meanwhile, institutions are conceptualized as the rules that norm behavior (e.g. laws, culture, routines, regulations) (Binz et al., 2016). It is shown that the alignment process results in the formation of key resources that are needed for the industry to evolve and new paths to emerge. Binz et al. (2016) condensed this resources into four: knowledge, niche market, finance investment and technology legitimacy. Knowledge is conceptualized as the key resource for new path generation (Bathelt & Glückler, 2005), it is conceived as having both tacit and explicit dimensions and experience and network-based know-how. Niche markets or markets, in general, are the markets for new technologies, that usually do not exist and must be created for the technology to be commodified. Finance investment is usually absent in the very early industrial phase of a new technology. Hence, different activities are usually made to mobilize finance from different sources like angel investors, venture capital and commercial loans (Binz et al., 2016), these can be either local or international. To finalize, technological legitimacy is considered as the alienation and legitimization of a new technology to the local institutional context through the development of regulative, normative and cognitive institutions (Binz et al., 2016).

The four resources outlined above (knowledge, market, finance, and legitimacy) are the main unit of analysis of this thesis research. Hence, the thesis will place attention in identifying how policies promote resource mobilization for the development of the SWH and PV industries. In order to answer this question, an understanding of the common frameworks that enable resource mobilization needs to be done, two frameworks are being studied. The first is known as catching- up and considers the importation of resources from outside of a region and the adoption of these resources by the local context, capacity building efforts made at the domestic level to adopt the technology are considered as part of the catching-up process. The second one is regional branching which is considered a local innovation process that obtain resources locally through technological related innovation processes.

i. Catching – up

Catching-up policies are based on the study of transnational linkages and the processes in which knowledge flows from one region and is anchored into other. (Binz et al., 2017, 2016) Anchoring describes the modalities and institutional arrangements that have to be done by an immobile phase (a region) to articulate a mobile context of knowledge and link it to a specific and immobile region (Crevoisier & Jeannerat, 2009), it means not only bringing new knowledge but adapting and modifying it to local conditions (Binz et al., 2016). The modalities and institutional arrangements to accomplish this are known as catching-up processes, which are measures specifically directed to obtain and "catch" extra-regional resources and link them to a specific location and conditions (Binz et al., 2017). Catch-up is a learning process that considers the modification and adaptation of the "nature, structure, organization, and dynamics of innovation and production sectors" (Malerba & Nelson, 2011, p. 1649) through a long-term learning process. A catching-up process implies the modification of the socio-technical regime through the obtention of key resources (knowledge, market, finance, legitimacy) and anchoring them to the socio-technological system through alignment processes between actors, networks or institutions.

Literature has shown that the state has a critical role in promoting the development of new paths in emerging economies through catch-up policies (Binz et al., 2017). The tool that governments use to promote the importation of resources are policies, which enable a region to catch resources up and anchored them to the local socio-technical systems.

ii. Regional branching

One of the main research agendas of evolutionary economic geography tries to understand the drivers of new path development on a regional scale (Boschma & Martin, 2010; Boschma & Frenken, 2012). Boschma et al. (2012) describe how the geographical concentration of industrial activities increases the efficiency of firms due to the agglomerated competition and the opportunities of collaboration among companies and can foster start-ups, innovation, and emergence of new related firms by taking knowledge from one company and using it for new ones. Several theoretical concepts have been developed from these observations, one of the most known one is regional branching.

Regional branching is a process in which firm organizational routines are transferred to other emerging companies in the same region, this transfer takes normally place through spillovers (labor mobility or spin-off firms) and can occur in two ways, the first considers the growth of an new sector from and old one, while the second one considers the formation of a new sector from the recombination of competences coming from different sectors (Ron Boschma & Frenken, 2012) . Routines are combined with different and new knowledge from other companies to develop new routines (Boschma & Frenken, 2011). It is considered that regional branching is a path-dependent and place-dependent process that promotes economic and regional development (Martin & Sunley, 2006).

One of the main research lines of branching processes is technological relatedness. It assumes that new firms evolve from technological related industries across regions

(Asheim, Boschma, & Cooke, 2011). It takes place because new technological and market opportunities develop during the time, as a consequence new firms emerge and try to exploit these opportunities. Afterward, market competition only allows the most successful firms to survive (Binz et al., 2016). Promotion of regional branching processes can also be done by the state through policy. It is important to mention that regional branching is a local innovation process but not equal to it. Other local innovation processes also exist; however, this thesis is focused on the regional branching phenomena that occur due to the technological relatedness between SWH and PV systems.

In relation to this research, it is assumed that the promotion of the development of SWH and PV industries and the obtention of resources is promoted through policy and follows a two-sided approach. On one hand, resource obtention is promoted through catching-up policies that aim for the importation of resources and anchoring them to the local context. On the other hand, local innovation processes are promoted, especially those related to regional branching and technological related processes. It is important to mention that both approaches can work together, regional branching can provide the resources to set the region ready to catch-up extra-regional resources. It is the aim of this thesis to understand what kind of policies promote resource obtention and through which approach (catching-up or regional branching) are these resources most likely to be obtained. The characteristics of the technology will be useful to answer this question.

2.2. Technological characteristics

This research is going to consider the theoretical considerations described before to analyze the policies that promote the emergence of SWH and PV industries in Mexico for the housing sector. Malerba et al. (2011) described how the development of a sector in one region contributes to knowledge spill-overs that impact on others within the same country (e.g. telecommunications to software, and agriculture to food industry). Hence, it is expected that some of the resource obtention promoted by the policies will be derived from one technology to the other (SWH to PV) while others can be catch-up or develop elsewhere. Furthermore, in some cases, a mixed process between regional branching and catching-up can take place.

Distinct disciplines have demonstrated the importance of achieving a high level of understanding of the technologies in order to predict their future and design effective public policies for its development (Huenteler et al., 2016). Huenteler et al. (2016) developed a framework to analyze the complexity of a technology to understand how innovation processes take place for different types of technology. The framework analyses two characteristics: i) the complexity of product architecture and ii) the scale of production process.

On one hand, the complexity of product architecture is understood as "the number of sub-systems and components and the complexity of their interactions in the system" (Huenteler et al., 2016, p. 104). It entails the complexity of the technology by itself, a technology with a higher product architecture is commonly designed and produced for specific customers and considering special characteristics which are tailored to the context in which the technology is used. Huenteler et al. (2016) exemplify this locating wind energy as a system with a high degree of product architecture.

On the other hand, the scale of production process considers the "modularity of the system as well as the size and homogeneity of user demand"(Huenteler et al., 2016, p. 104). It entails the homogeneity and adaptability of the technology to different environments and conditions. Technologies with high scale of production processes are products that can (almost) be used anywhere, anytime and by anybody. Their main characteristic is its mass-production process that do not consider the characteristics of the environment in which it will be used. Huenteler et al. (2016) locate PV systems as a technology with a high degree of scale production process.

The analysis of technologies considering these characteristics commonly results in a trade-off between both characteristics. A technology that has a complex product architecture has a low degree of scale production process, while the technology with a high degree of scale production process has a low complexity of product architecture (Figure 1).

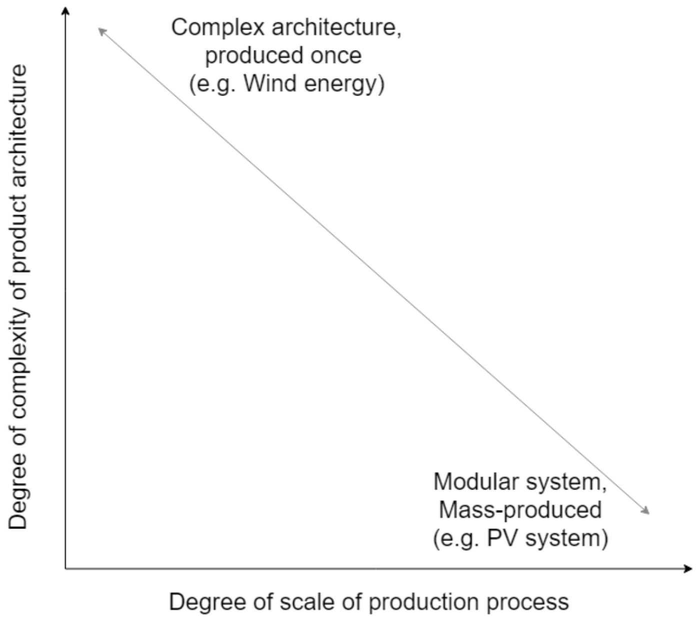


Figure 1: Framework to classify technology. Adapted from (Huenteler et al., 2016)

Huenteler et al. (2016) and Binz et al. (2017) used this model to analyze and compare different technologies, the former compared solar PV systems to wind power systems, meanwhile the latter compared the same while adding biomass technology as a third one. These approaches considered the comparison of different technologies to ensure the identification of clear differences and reveal insights. Binz et al. (2017) developed a specific set of criteria for the comparison of the technologies, considering the four resources that are mobilized in an early stage of an industrial development. These set of criteria outline policy activities that promote the access to the mentioned resources, Table 1 describes these activities in detail.

Resource	Activities
Knowledge	- Government funded basic science and R&D programs - Supporting the quick translation of new technologies to the manufacturing process - Support for entrepreneurial experimentation in private start-ups - Support imports of capital equipment, turn-key plants, and/or knockdown kits
Market	- Promotion of domestic mass markets to facilitate economies of scale in production. - Establishment of export processing zones with state-of-the-art trade infrastructure. - Interventions to decrease factor costs (e.g. raw materials and capital costs))
Finance	- Providing low-cost loans for plant expansion, equipment purchases - Creating a supportive private equity and venture capital system
Legitimacy	- Adopting quality certification and standard systems - Mobilizing policy/public support based on success stories.

Table 1: Resource mobilization catching-up policies. Adapted from Binz et al. (2017)

Considering a different approach to what Huenteler et al. (2016) and Binz et al. (2017) did, in which they compare different technologies, this research is comparing two similar technologies but with important differences: Solar Water Heating (SWH) and Photovoltaic (PV) systems. By considering the model described by Huenteler et al. (2016), these technologies have a similar scale of production process, both systems are standard, mass-produced products and installed in individual units (homes, offices, etc.) by technicians. Nevertheless, the complexity of product architecture varies between both. On one hand, SWH are simple systems that do not require higher levels of technical capacities to be built. On the other hand, PV systems are more complex, its manufacturing process requires more technical capacities, more investment, and knowledge. This difference adds complexity to the model developed by Huenteler et al. (2016), since technologies with similar scale of production process but different product architecture complexity do exist (Figure 2).

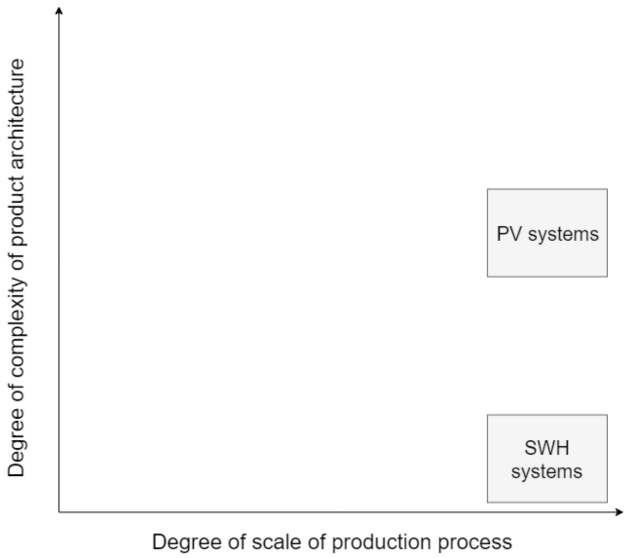


Figure 2: Classification of technologies. Based on Huenteler et al. (2016) *and Binz et al.* (2017)

The similar degree of scale production process and the higher degree of complexity of product architecture of PV systems in comparison to SWH is what makes this research interesting and valuable. It delivers useful contributions for the better understanding of promotion of resources for specific technologies through catching up policies and regional branching processes in an emerging economy context. It is argued that, due to the similarities, some of the resources are obtained locally, therefore its promotion follow regional branching approaches, while other resources, those related to the complexity of product architecture are promoted through catching-up policies.

2.3. Sustainable transitions in emerging economies

Traditional frameworks for sustainable transition analysis (e.g. TIS) were initially designed for developed contexts, especially European countries. That is why these frameworks do not totally fit in a developing or emerging context, these are characterized by a mixture of well and ill-functioning institutions, clientelist societies, market imperfection, inequality and social exclusive communities (Ramos-Mejía et al., 2016). A better understanding of how transitions occur in this contexts is necessary and urgent (U. E. Hansen et al., 2017; U. E. Hansen & Nygaard, 2013; Wieczorek, 2017). As a result, research focused on understanding transitions in developing and emerging economies has increased in the last years.

One of the main results of this research lines is the common understanding that new path development in emerging economies relies heavily on international resources due to the lack of locally innovation capacities (U. E. Hansen et al., 2017; Wieczorek, 2017). Hence, extra-regional resources and catching-up policies are crucial for the development of new paths. Nevertheless, it is important to have in mind that emerging economies have important differences between and within them. Some regions might be very well developed and have good innovation skills for certain industries while others might not (Ramos-Mejía et al., 2016). Consequently, a thorough consideration of local conditions is necessary, which is aligned with several critics made to TIS frameworks due to their unawareness of space and scale (Coenen, Benneworth, & Truffer, 2012; Coenen & Truffer, 2012; T. Hansen & Coenen, 2015).

The complex context of emerging economies, with low and high developed regions and sectors, increase the complexity to understand which resources are typically obtained locally (e.g. regional branching) and which other are obtained from the outside (e.g. catching-up policies). That is why testing these frameworks, by comparing policies and identifying the common approaches that promote new path development in an emerging economy like Mexico will expand the empirical cases to better understand sustainable transitions in emerging contexts.

3. METHODOLOGY

This chapter describes the methodological approach considered for this research, the first part described the general design of the research and the reasons why this approach was selected. The second part described the methods in detail, by describing how the analyzed documents were selected and how its analysis took place.

3.1. Research design

The design of this research is based on a policy analysis that seeks to identify how policy promotes the mobilization of knowledge, market, finance, and legitimacy. The journal of comparative policy analysis describes that the most common methodology to compare policies is through an analysis of a historical case-based study (Geva-May, Hoffman, & Muhleisen, 2018). Such an analysis *"draw conclusions by comparing different countries, localities and policy regimes, often over a period of time. They do not attempt to delimit any set of texts or sources for analysis, but rather freely mix scholarship, journalism, government reports and other sources"* (Geva-May et al., 2018, p. 28). This kind of analysis is qualitative research which encourages researcher to incorporate multiple approaches, methods or techniques into the research practices to convey different realities through creative and interpretative approaches, this allows the research to identify an expand the set of variables or characteristics concerning an issue from different perspectives towards a better understanding of the problem (Denzin & Lincoln, 1994).

Equally important, the case study is considered as an appropriate model to analyze qualitative research and for this research, because it provides an in-depth picture of a unit of study as an exploratory form of inquiry and is better suited to answer questions about 'how' and 'why' (Stewart, 2014). An important element of a study case is the definition of the boundaries, which is a process made by the researcher with the aim to set the research boundaries and limit the scope of analysis (Stewart, 2014). Given these points, the design of this research considers the implementation of a historical case-based study that compares policies developed to promote the obtention of resources for new path development for sustainable technologies in an emerging economy context, specifically policies developed to promote the Solar Water Heating (SWH) and the

Photovoltaic (PV) industry from around 1980's until present days in Mexico are considered.

The case study is selected due to several reasons, the feasibility to compare the promotion and development of both industries in a same timeline and context will develop insights for sustainable transitions theory, especially in a Latin American emerging context, which is not thoroughly researched yet. Furthermore, both industries are expanding due to transnational and local resources, hence these cases can develop useful insights to understand the kind of resources that are usually develop locally and those that are brought from the outside. In addition to that, the possibility to compare these two technologies, considering its similarities and differences make the case study even more interesting. As a personal note, the researcher background is Mexican and is a motivated person about the introduction of this technologies in the country, which adds to the decision of both study cases.

3.2. Research methods

The methodology for this study is based on a desktop research from 27 policies promoting the development of the SWH and PV sectors in Mexico. The solar energy sector in Mexico has been active since around 1950's. However, efforts to foster the industry were made since the 1980's, that is why the review of information considered for this study goes from around the 1980's until 2018.

The process for analyzing the policies comprehend a two-step process. First, a policy library was compiled, the aim of this step is to find the required documents and to get a first approach of how these documents developed over time. Afterward, on a second step, the data is carefully read and analyzed to understand and identify how resources are promoted by policies.

First step: policy library

The development of the policy library involves the identification of different sources of information that describes the implementation of policies, the main source of information are official policy documents from the Mexican government. However, other sources of information like project, results, NGO's and international agencies reports are also considered. The main characteristic to consider a source viable for the research was the resource promotion (knowledge, market, finance, legitimacy). If the source described the promotion or promoted by itself the development of one of these resources for the SWH or PV industry, it was considered as a pertinent source and included in the library. The methodology to find the sources was based on a purposive sampling technique that considers the knowledge and experience of the researcher as the main criteria to judge which element is sampled; the main objective of this sampling technique is to define a representative sample that covers the necessity of the research (Battaglia, 2011). The internet-based search was implemented through two main websites: Mexican government official website (www.gob.mx) and google search engine in its normal version (www.google.com). The research library included 27 policy sources (see appendix 1).

Second step: Documents analysis

The second step of the methodology was the core of the thesis, it consists of the analysis of the policies, accomplished by reading and coding them. The process of coding is described as a *"close exploration of collected data and assigning it codes, which may be names, categories, concepts, theoretical ideas or classes. It also involves writing memos or thoughts and ideas, associated with given codes, elaborating and linking codes, and thinking about what they mean in the context of a broader argument or story"* (O´Reilly, 2012, p. 2). Having this in mind, the process to analyze the policies consisted on reading each document and coding it, the codes developed were based on the resources that are promoted by the policies, which is what the process tried to identify, consisting on four codes: knowledge, market, finance, and legitimacy. A memo was written to describe the activities that are promoted to obtain each specific resource. The coding process was held using the software NVivo 11.

The results of the codification process (including the memos) were exported into an excel table for further analysis. The analysis derived in the development of a policy typology (Appendix 1). This was done to achieve a better understanding of the policies. A Typology is the study of types or the art of dividing things into types (Cambridge, n.d.), hence a policy typology will divide the policies into types that are considered useful for the task assigned. Considering the objectives of the research of identifying which resources are promoted and if these are promoted through catching-up policies or through regional branching processes, the main types considered are laws, regulations, initiatives, projects, studies. This typology was used to link the specific resource promotion with international or national efforts, Table 2 describes the characteristics of each type of policy considered.

Policy typology	Description
Law	Law enacted to promote SWH or PV. Promotion of national and/or international measures are considered.
Regulation	Development of standards or technical regulations for the SWH and PV sector.
International Initiative	Initiative (e.g. programs, projects or plans) developed by the Mexican government in cooperation with an international entity to promote the sectors.
National Initiative	Initiative (e.g. programs, projects or plans) developed by the Mexican government to promote the sectors.
Actors (NGO's, research centers, organization)	Actors that were formed to promote the development of the sectors. The formation of these are considered policies because these were created under policy frameworks with specific objectives, which include resource obtention

Table 2: Policy typology description

After the development of the typology, the historical analysis of the policy development was made. A variety of policies at the federal level affect both sectors together, that is why the analysis was not divided per sector. However, the period was divided in three phases to gain a better understanding of the policy development, the resource obtention promoted and the linkages between SWH and PV. The first phase goes from around the 1980's to 2000, it is considered as the solar energy emergence period, it is characterized by the low involvement of the state, the development of the sector was mostly pushed from the side of the society. The second period is from 2000 – 2013, during this time the state increased their involvement in solar energy promotion by developing regulation, laws and knowledge obtention from national and international sources. These days are also known to be the days when the SWH consolidated as a feasible and trusted technology. To finalize, the third period is from 2013 until 2018, these are the first years after the energy reform, which changed the rules of the game by providing a new legal framework, efforts to promote resource obtention were made through both national and international sources during this time. After defining the three phases, a diagram was made (Figure 3) which aims to help to answer the question about the role of the technical characteristics in the promotion to develop resources. The diagram is based on a timeline from the period analyzed, it shows information considered important to answer the research questions, which includes the types of policies, their importance, the resource mobilized its origin, and the sector affected.

4. MEXICAN SWH AND PV INDUSTRIES

Mexico is one of the countries in the world with higher solar radiation and best solar energy possibilities, with an average of 5 kWh/day/m^2 (SENER & GIZ, 2012), almost the double radiation as in Germany (Mata and Ortega, 2015). However, due to carbon lock-ins (Unruh, 2000), these resources were not exploded until the last decades. For 2016, the share of renewable energy production in the country was 8.4 percent, meanwhile, the share of solar energy was only the 0.15 percent (Energy Ministry (SENER), 2017)

4.1. Forms of using the solar energy

Two main forms of exploiting solar energy exist. The usage of the thermal heat of the sun to heat liquids using Solar Water Heaters (SWH) and the conversion of the photon energy of the sun into electric energy using photovoltaic (PV) panels. The SWH industry harness the heat of the sun to heat the liquid, principally water, to low temperatures (below 100°C). This process is done conventionally with common boilers by burning natural gas, liquid petroleum (known as LP-Gas) or wood in the locations where the heated water is required. It is estimated that the energy consumed in Mexico for conventional low-temperature water heating during 1996 to 2005 was the 6% of the total energy consumption (CONAE, ANES, & GTZ, 2007). Solar water heating (SWH) could substitute the conventional method in high proportions.

SWH is a simple technology that only requires one device and some installation configurations to heat water for domestic use. Two common types of SWH exists. The flat plate collector and the evacuated pipelines collector. The former is a flat black collector, made from glass or polycarbonate that contains pipelines -usually made from copper- where water flows and receive the heat collected.

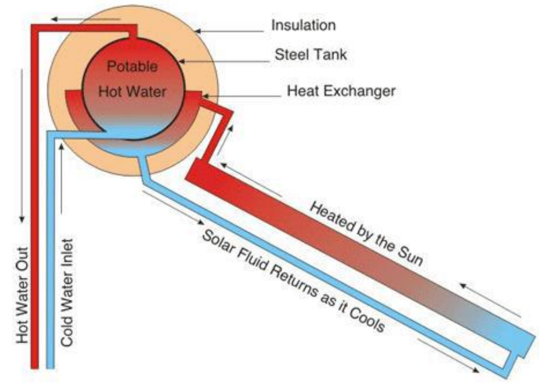


Image 1: Flat collector. Retrieved from http://mamataenergy.com/wp/fpc-flat-plate-collector/

The evacuated pipelines heater consists of several vacuum glass tubes that contain water that is heated and transferred to an isolated tank. The main difference between the collector is that the efficiency of the evacuated tubes is higher, meanwhile, these are more fragile. Furthermore, their production process is more difficult and requires higher technological capacities.

Image 2: Evacuated pipes collector. Retrieved from https://www.prosoleco.com/energia-solar/calentadores-solares/

The first SWH builders in Mexico appeared around 1942 (Rincón Mejía & Aranda Pereyra, 2006), they were specialized in heating water for pools. However, during the last decades, from the 1980's onwards, different policy packages and measures have been implemented to promote the industry, consequently, it has gain importance in the commercial, small industries and especially in the housing sector. One of the main barriers to the implementation of SWH is the fossil fuel subsidies, which have been decreasing in the last years, opening the market for the SWH.

The photovoltaic systems, as described before, are used to produce energy by converting the photon energy of the sun into electric energy. This industry is smaller in Mexico in comparison with the SWH's one because the technology is more complex, and the national regulatory framework was not prepared for this technology, which hindered severely its development.

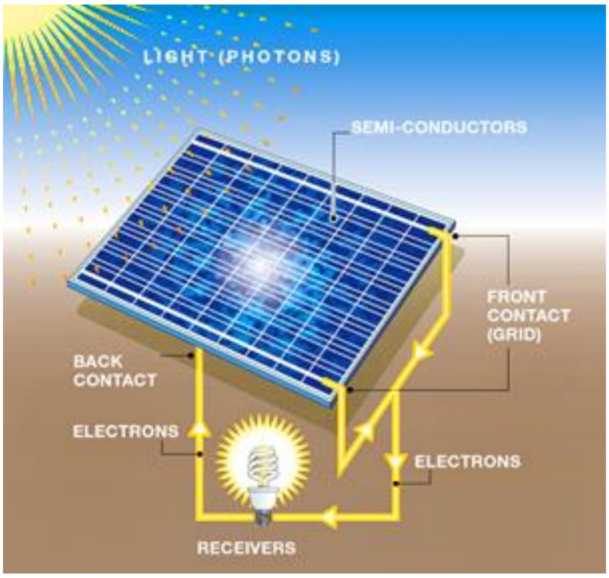


Image 3: Solar photovoltaic panel. Retrieved from https://www.csisun.com/solar-pv/ (CSI SUN, n.d.)

The promotion of the PV sector required several institutional and regulatory reforms. As part of this reforms, some studies took place to identify the most appropriate sector in which the PV technology could be implemented, the result -in line with the SWH sector- was that the housing sector was the most appropriate (Amtmann, 2009). Since then, efforts were made to promote the adoption of the technology, especially in this sector. However, important barriers needed to be considered, the main one was the subsidy to electricity that remains in the country.

4.2. The distributed generation framework and the energy reform

The PV industry, as an energy producing sector, had special regulations that hindered its development. The first and most important is that the Mexican energy sector was a monopoly managed by the state, the state used to produce and distribute the energy to the whole country and nobody else was allowed to do that. With the emergence of renewable energies and the relevance of the private sector in the development of them, different reforms to the regulatory framework were made to enable the private sector to participate in the energy mix of the country. This thesis is concerned with two of them: the distributed generation framework and the energy reform.

The distributed generation framework was developed to allow small producers, especially private homes, to produce energy for auto consume and to connect their products to the national energy grid so that the surplus of production could be sold to the national energy entity. Before of that, private owners were allowed to have their own production, however, it could only be used in a local microgrid and couldn't be sold, which required a much bigger investment due to batteries requirement. This model hindered the PV sector severely. The first reform for the implementation of the distributed generation model was done by 1992. However, by 2007, a specific regulation was made for solar PV systems for the housing sector. This reform to the regulatory framework is considered as a big game changer for the PV industry.

In relation to the energy reform, the Mexican energy framework was monopolistic, and state-controlled until 2013 when an energy reform took place that changed the regulation and allowed the private sector to be part of the energy production mix. Before of that, only small auto consume producers were permitted. After the regulation, big producers are allowed to produce and sell energy, which was a game changer for renewable energies in general and fostered the development of renewables, including the SWH but specially the PV industry (Hoyt, Olivas, & Grajales, 2006; Rodríguez Suárez et al., 2017).

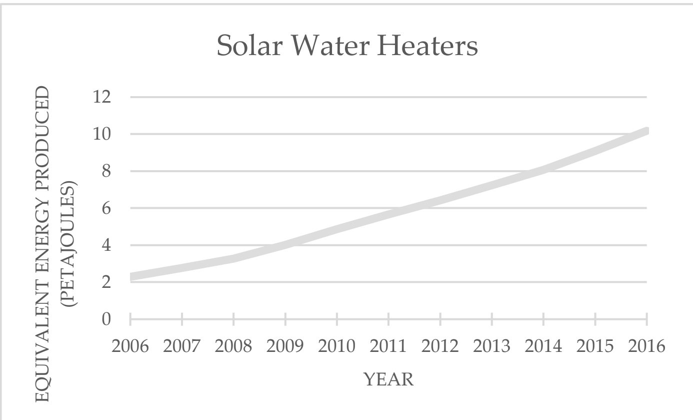
4.3. Industrial profile of SWH and PV industries

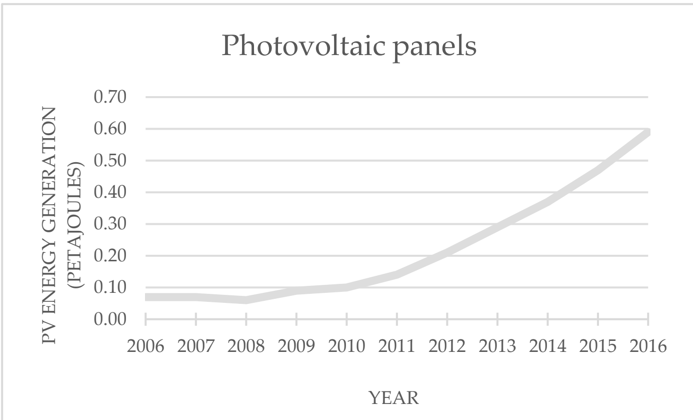
The Mexican SWH and PV industries are at different industrial stages, the SWH has a bigger presence in the country. However, the PV industry has grown importantly in the last years and, due to regulatory arrangements described before, it is expected to grow more in the coming years. This section is going to describe the state of the art of both industries in the country.

The National Energy Balance of Mexico of 2016 show information of the development of the solar energy industry in the last years. Box 1 summarizes these statistics, as it is shown there, both industries have grown considerably. On one hand, the SWH industry has been growing faster and steadier, generating the equivalent energy to 10.18 petajoules, on the other hand, the PV systems have also been growing, for 2016, it generates 0.59 petajoules. The interesting part of PV systems is the proportion of interconnected systems, which is 90 percent. These are private medium and small systems connected to the national electric system following the distributed generation framework (CRE, 2017).

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
SWH Installed per year (thousands of m²)	97	154	166	233	273	272	270	293	309	356	381
Total SWH installed (thousands of m²)	840	994	1,160	1,393	1,666	1,938	2,208	2,501	2,810	3,166	3,547
SWH equivalent Generation (PJ)	2.29	2.77	3.27	4.01	4.86	5.66	6.43	7.24	8.06	9.09	10.18
Growth rate	ND	0.60	0.07	0.41	0.17	0.00	-0.01	0.08	0.05	0.15	0.07

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Installed PV in the year (kW)	1,056	901	872	5,712	3,502	10,400	20,900	22,280	33,970	42,637	39,730
Total PV installed (kW)	17,633	18,534	19,406	25,118	28,620	39,020	59,920	82,200	116,170	158,807	198,537
Proportion of interconnected PV systems (%)	0.00	0.00	0.02	0.02	0.19	0.24	0.43	0.64	0.90	0.90	0.90
PV Generation (PJ)	0.07	0.07	0.06	0.09	0.10	0.14	0.21	0.29	0.37	0.47	0.59
Growth rate	ND	0.05	0.05	0.29	0.14	0.36	0.54	0.37	0.41	0.37	0.25





Box 1: Information of SWH's and PV systems from 2006 to 2016. Adapted from National Energy Balance (Energy Ministry (SENER), 2017)

In relation to production and manufacturing of SWHs and PV systems. Mexico has a long history of SWHs manufacturers, nowadays every variety available in the market is being built (flat collector, evacuated tube) and several Mexican companies built them. Table 3 shows the main producers of SWH in Mexico. Most of these companies are Mexican and are based on Mexican technology.

Name	Foundation date	Origin	Location	Production capacity (MW)
Captasol	1981	Mexican	Celaya, Gto.	29000
Depsa[1]	~1970	Mexican	Guadalajara	40000
Frantor[1]	NA	Mexican	Arandas, Jalisco	93600
IUSA[2]	1939	Mexican	Edomex	18000
Kioto	2009	Australian	El Salto, Jalisco	NA
Modulo solar	1975	Mexican	Edomex	80200
Sunway	1980	Mexican	Mexico City	2200
Tecnosol	1969	Mexican	Guadalajara	NA

Table 3: Main SWH's producers in Mexico. Adapted from Rodríguez-Suarez et al (2017)

As presented above for SWH's, Table 4 presents the main producers in Mexico of PV systems, only two of them are Mexican companies, the others are mostly transnational companies that manufacture products in Mexico to sell them in the USA (Rodríguez Suárez et al., 2017). Nevertheless, it is important to mention that the bigger producer is the company IUSASOL, founded in 2014, and subsidiary of the electronic company IUSA, which was founded in 1939 and produces several products, including SWH's and PV systems, it is important to note that the production plant of IUSASOL is the biggest in Latin America ("IUSASOL : LLevamos El Sol a Tu Vida", 2018).

Name	Foundation date	Origin	Location	Production capacity (MW)
ERDM solar	2003	Mexico	Veracruz	60
IUSASOL	2014	Mexico	Mexico state	500
Jabil Circuit	2000 (in Mexico) 2009 PV panels	USA	Chihuahua	45
Kyocera	1987 (in Tijuana), 2005 PV	Japan	Tijuana	150
Panasonic	1979 (in edomex) Start of PV production unknown	Japan	Mexico state	75
Risen energy	2014	China	Durango	400
Sunpower	2011	USA	Mexicali	425
Solartec	2013	Mexico	Guanajuato	72.5

Table 4: Main PV systems producers in Mexico. Adapted from Rodríguez-Suarez et al. (2017)

[1] Producer of evacuated tubes and flat collector SWH's

[2] The company IUSA was founded on the 1939, they started with the production of SWH 1980.

4.4. Study focus on domestic sector solar energy

This thesis research considers the promotion of the SWH and PV industry for the housing sector as the main sector analyzed, the reason behind is that the development of these industries started in the country in this sector (housing), and the policies to promote its development – which are the policies analyzed here-, were design to foster the implementation of solar energy in the housing sector.

Two studies were developed to define which was the best alternative to introduce these kinds of technologies in the country. The study *Financial Alternatives for promoting the use of Solar Water Heaters in the Domestic Mexican Sector* (Hoyt et al., 2006) and the study *Market niches for photovoltaic systems connected to the national Mexican grid* (Amtmann, 2009), described the main barriers for implementing these systems, which were the subsidies to fuels and energy and the lack of adequate financial mechanism for the higher investment costs.

In relation to the SWH industry, the main barriers were the subsidies to gas use for heating water in the housing sector, the limited access to finance and the lack of norms or standards. These, bounded with the higher initial investment required, made the development of the sector difficult (Hoyt et al., 2006). However, the aforementioned study showed that the housing sector was the best alternative for the development of the SWH industry because fuels prices were expected to increase, better financial mechanisms were developed, and investment costs were expected to decrease due an increasing offer and industry.

Considering the PV industry. The study made to identify the best market niche for its development showed that the best sectors to implement PV systems were the housing and commercial one. The main reason behind this was the subsidies to electric energy and the national energy regulatory framework of that day (2009). In relation to the energy subsidies, Mexican electricity system for the housing sector is organized in tariffs that change with the amount of energy used. The subsidy applied by the government decrease if the amount of energy increase, hence if a certain amount of energy is surpassed the price increases considerably. The houses that fall in this consumption level were the perfect targets for the installation of solar PV systems because the installation of a small system would reduce the energy consumption and allowed them to benefit from the subsidy. Furthermore, the energy reform that took place at 2013 increased the demand for PV systems in the domestic and commercial sector because of the possibility of selling the energy to the Mexican energy system. (Hoyt et al., 2006; Rodríguez Suárez et al., 2017).

This thesis is based on the growth of the SWHs and PV industries in the housing sector because the main efforts – through policies- that have taken place in the last decades were directed to increase the use of SWH and PV system in the sector mentioned. Next section will describe and analyze these policies.

5. POLICY BIOGRAPHY

This chapter consists on the first part of the policy analysis, the main outcomes are the identification of the types of policies that promote resource obtention, the identification of the origin of the resources promoted and the understanding of the linkages between policies and sectors (SWH and PV). The aim of this section is to set the ground towards the understanding of how each specific resource is promoted, which is discussed in chapter 6. The analysis considers a policy biography to describe the development of the SWH and the PV sectors in Mexico. As described before, the whole period analyzed is divided into three sections, each section includes a summary table that described the type of policies that promotes resources and its origin. It is important to mention that both sectors are considered part of the renewable energy sector, therefore a variety of policies were developed for renewable energies impacting on both (SWH and PV) sectors. That is the main reason why this section is not separated into technologies. However, where necessary, specific inputs about each sector are made. Figure 3 illustrates the policy development process in a timeline. The details of the activities and resources promoted by each policy can be seen in appendix 1.

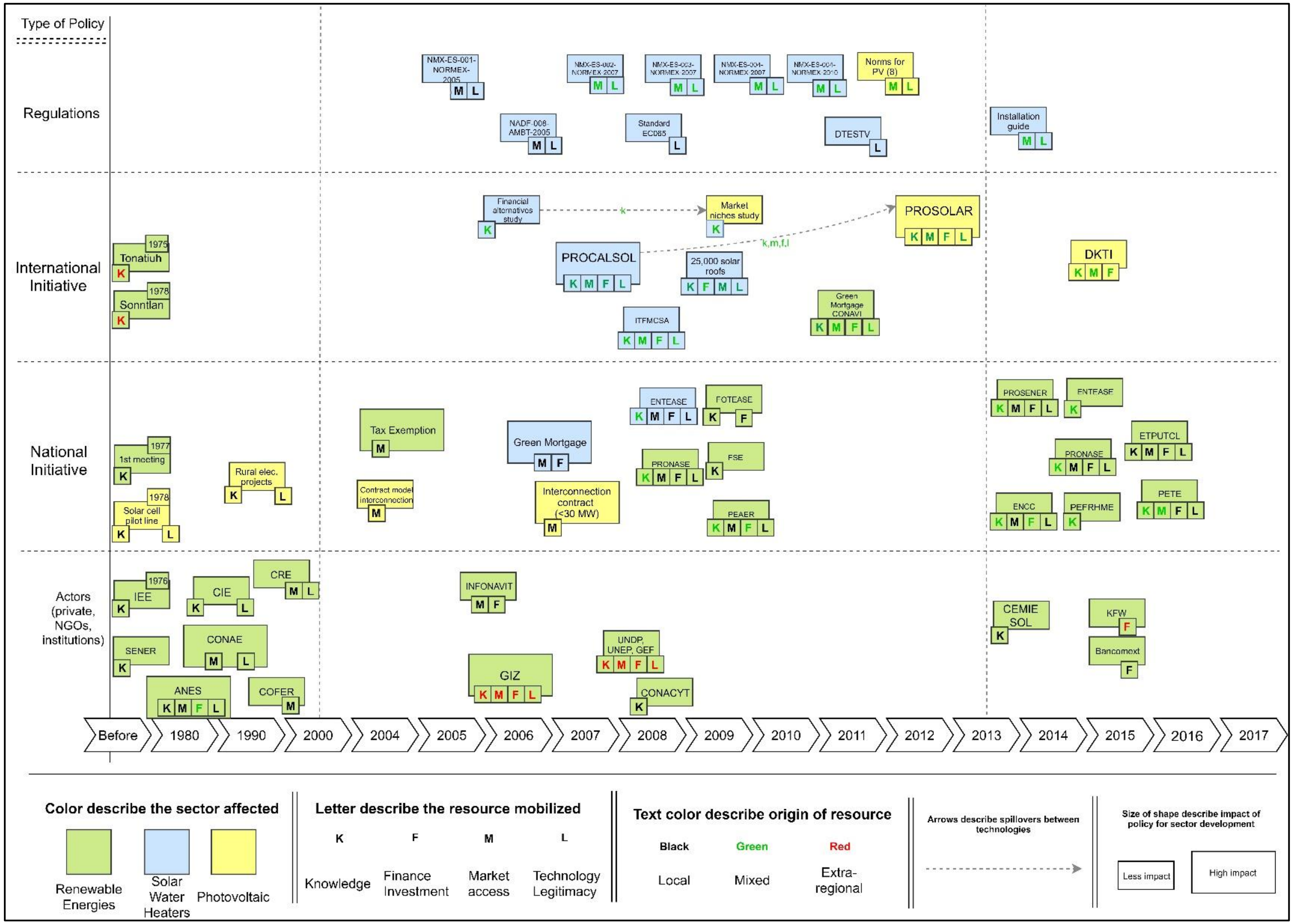


Figure 3: Policy analysis timeline/diagram

5.1. 1980s' – 2000 Solar energy appearance.

During the 80's, several initiatives took place around solar energy that consolidate it as an emerging niche (Coenen, Raven, & Verbong, 2010). Solar energy research centers were being developed, national meetings for information exchange started to occur, and the national association for solar energy (ANES) was created. These activities helped the country to form a solid knowledge base, the formation of ANES was very important because later it became a crucial actor for solar energy promotion and innovation (Rincón Mejía & Aranda Pereyra, 2006).

During these days no specific policy to promote the solar energy sector was made, the state was almost absent. It only appears through the project *Tonatiuh* and *Sonntlan*, both were cooperation projects to promote technology transfer, the former from France and the latter from Germany. On one hand, the *Tonatiuh* project aimed to provide access to water for communities in arid and remote areas by pumping water with solar energy, the main reason of the failure of the project was the incompatibility of the French technology with the Mexican standards. On the other hand, the *Sonntlan* project aimed to develop a coastal fisherman community in Baja California Sur by developing a system to provide drinking water, ice, freezer units, and electricity. The project failed due to the unawareness of local conditions and the low efforts for maintenance and community integration (Rincón Mejía & Aranda Pereyra, 2006).

In relation to these projects, it is important to highlight the unawareness and the low involvement of the state in solar energies during these days. According to the ANES (Rincón Mejía & Aranda Pereyra, 2006), both projects were implemented in a top-down approach with the aim to establish good cooperation relations with France and Germany and to transfer technology, but not to provide solutions for the community. The state was not interested in developing renewable energies because of the importance of the oil production for the country, which was the main source of income, and consequently a carbon lock-in (Unruh, 2000) against renewable energies. These two experiences highlight the importance of catching-up policies to link and adopt extra-regional knowledge to the local context.

The first formal builders of SWH appeared in the country around 1980 (Modulo solar, n.d.; Sunway, n.d.; Tecnosol, n.d.), some of these companies (e.g. IUSA) were already existing in the country producing other appliances and identified the window of opportunity (R. A. Boschma, 1997) of SWH and diversified to that sector. The development of these companies was related to the research centers that were appearing, both gave positive feedback to the other so that these could emerge (Rincón Mejía & Aranda Pereyra, 2006). These relationships promoted the development of a pilot production line for solar PV cells, which was the first action in the county for the development of the PV industry, whose development was severely hindered due to the regulatory framework.

The Electric Power Public Service Law (LSPEE) established in 1975 that the central Mexican government, through the Federal Energy Commission (CFE) was the unique entity with the allowance to generate, transport, transform and distribute electricity in the country (Congreso de la Unión, 1975). This hindered severely the development of photovoltaic energy. The first policy intervention that changed this was in 1992 when the LSPEE was reformed to allow the production of energy for cases not considered as public service, which includes power generation for self-supply. This update of the energy regulatory framework, in coordination with the research centers, improved the market conditions and fostered the development of PV sector.

During the 90's the involvement of the state in the energy promotion changed with the creation of institutions to promote energy efficiency and renewable energies, to regulate energy markets and to diffuse information about successful projects. In line with this, a variety of successful electrification projects for the rural sector all over Mexico appeared (Páramo-Fernández, 1997; Rincón Mejía & Aranda Pereyra, 2006). These actions located the state as a major stakeholder for the promotion of renewables energies and created legitimacy about solar energy, especially PV, by communicating the successful results of the rural electrification projects.

This first period was characterized by the formation of actors to promote renewable energies in general, that is why it is considered as the building blocks phase in which the basic framework for the promotion of renewable energies by the government was formed. Figure 3 illustrate this by showing a higher density of rectangles in the actor's section. Therefore, the type of policies that promoted resource obtention during this period were mostly actors, national initiatives, and international initiatives. The main resource promoted was knowledge, nevertheless the other three resources were also promoted. The promotion made by the international initiatives are considered as not relevant due to their unsuccessful results. The most common approaches for resource obtention were done at the national level through technological related local innovation processes, it can be assumed that regional branching processes between SWH and PV took place. However, transfer of resources from electronics sector to the PV one is also considered. The common sectors targeted during this period were renewable energies in general, although some efforts specialized in photovoltaic energy were also identified, this took place mostly towards legitimization and knowledge development. The only sign of transnational resources took place by the development of finance, which was done by the actor ANES.

Table 5 summarizes the resource mobilized during this period, the type of policy and the origin of the resource promoted. It is not totally possible to identify the approach used to promote resources by analyzing the policies, that is why the origin of the resource is used as a proxy to identify the approach promoted. For the aim of this research it is assumed that if the resource is local the approach is based on local innovation processes, while if the resource is extra-regional the approach is catching-up. As mentioned before, mixed approaches also exist, where local and extra regional resources are used for the same objective.

Resource	Type of policy	Origin of resource	Sector impacted
Knowledge	- Actors	- Local	- Renewable energies
	- National initiatives	- Local	- PV - Renewable energies
	- International initiatives	- Extra-regional	- Renewable energies
Market	- Actors	- Local	- Renewable energies
Finance	- Actors (ANES)	- Local - Mixed	- Renewable energies
Legitimacy	- Actors	- Local	- Renewable energies
	- National initiative	- Local	- PV

Table 5: Resource mobilization summary, first period.

5.2. 2000 – 2013: Promotion of solar energy by state becomes reality

After the year 2000, the state took an important role in the promotion of solar energy, especially SWH. The most important outcomes of this period were the development of new laws, regulations, studies and specific initiatives to promote the mobilization of characteristics resources from early industrial development processes (Binz et al., 2016). These processes included the local and extra-regional mobilization of resources. Among these processes, spillovers between industries stands out. This active period helped to consolidate solar industry in the country, and the role of the state for its promotion. One of the main facts that showed the interest of the government to promote renewable energies was the reform to the income tax law to include the exemption of hundred percent of the cost of machinery and equipment acquired for renewable energy generation like SWH and PV systems (Congreso de la Unión, 2013). This was considered as one of the key policy mechanism that fostered the development of SWH.

In relation to regulation for the PV sector, in 2001 a contract model for interconnection between a particular small self-supply power generator and the national energy transfer grid was published, the aim of this contract was to make the connection of renewable energy projects to the national electrical system possible (Gobierno de la República Mexicana, 2009; SENER, 2001) This regulation was improved in 2007, by developing a special contract for solar energy for the housing sector, this contract was specially designed to increase the amount of generated distribution of small energy producers.

From 2005 to 2010 a critical period for the development and promotion of the SWH sector started, this included regulatory, financial, market and knowledge creation mechanisms that boosted the development of the sector. Figure 3 shows an important density of blue rectangles, mobilizing the four types of resources.

In relation to the regulatory framework, several voluntary norms and standards were developed (e.g. NMX-ES-001-NORMEX-2005). Aligned with these, Mexico City government pushed a regulation on buildings to promote domestic mass market by obliging developers to install infrastructure to heat at least 30% of water usage per building with solar energy. The aims of this norms and standards where ensuring minimal quality requirements during production and installation, technical specifications and functioning and maintenance of SWH’s (ANES, CONAE, & CONCYTEG, 2005; Gobierno del Distrito Federal, 2006). It is important to mention that the research centers, private and NGO’s sectors, through the ANES, played a key role in the development of these standards. These regulations and standards derived later in other regulations for both SWH and PV sectors.

Transnational linkages and catching-up processes for the promotion of SWH appeared in 2006 with the study *financial alternatives for the promotion of the use of SWH in the domestic Mexican sector* (Hoyt et al., 2006), which was done by the CONUEE (called CONAE in those days) in collaboration with the German agency for cooperation, the GIZ (called GTZ in those days). The aim of the study was to identify the best financial mechanism to support the development of the SWH domestic market in Mexico. The results showed that the best option was the development of the SWH in the housing sector and to include its cost as part of the housing mortgage. However, it also showed that the low prices for subsidized gas and electricity were an important barrier for the development of the sector. One of the most important outcomes of the study was the development of the project PROCALSOL and the beginning of a long and beneficial process of cooperation for solar energies between the German and Mexican government. This cooperation delivered different catching-up process that helped to bring solar German resources into the country.

The program for the promotion of solar heaters (PROCALSOL) was launched by the CONUEE in 2007, in collaboration with the GIZ and ANES. It objective was the promotion of the SWH for the housing sector, the strengthening of the market and national industry (producers, system designers, distributors, and installers) and the technological development and national research centers. This was accomplished through four main strategies that aimed to impact on specific barriers: 1) regulation to increase legitimacy by developing a system that ensures quality; 2) financial incentives to promote domestic markets and financial investment by developing economic mechanisms to promote the demand of SWH by reducing the initial investments and raise private bank awareness for the development of financial schemes for the acquisition of SWH; 3) Strengthening of offer to promote domestic markets by reducing the initial investment costs through supporting producers, take advantage of low interest rate to finance SWHs and increase the offer of qualified technicians and installers, and 4) information and management to increase legitimacy by reducing distrust of potential users by providing information (CONAE et al., 2007).

The PROCALSOL was a successful project that generated alliances, new projects, and different outcomes. Three outcomes are important to mention, the first one is the alliance with "Hipoteca Verde" (Green Mortgage) program, which was a governmental pilot project, promoted by the Institute of the National Housing Fund for Workers (Infonavit), that granted an extra amount of money for the acquisition of energy efficient equipment for the housing sector. Due to its success, it started a joined venture with PROCALSOL to promote SWHs in 2007. By 2011, Infonavit granted 36,973 green mortgages with SWH's and had a growing tendency (CONUEE, GIZ, & ANES, 2011). Nowadays, the Green Mortgage program has become a worldwide referent for facilitating financial investment to foster ecotechnologies, it received the 2012 World Habitat Award (BSHF, 2016). The finance given by the green mortgage during PROCALSOL alliance were national funds. From 2011 onwards, the program was modified and adapted to the different bioclimate regions of Mexico and made mandatory for every Infonavit mortgage. The National Housing Commission (CONAVI) took the lead of the program.

The second one, was the alliance between the UNDP, UNEP, GEF and CONUEE for the project *Transformation and strengthening of the Solar Water Heating market initiative (ITFMCSA)* which aimed to develop a favorable regulatory framework, increase market demand, strengthen the supply chain, reach 2.5 million of square meters of installed SWH surface by 2012 and facilitate sustainable growth of the market (UNDP, UNEP, & GEF, 2009).

Finally, the third one was the project "25,000 solar roofs for Mexico" which increased the funding capacities of the Green Mortgage. Its main objective was to promote and encourage the use of renewable energies, especially SWH, and to remove barriers that inhibit their use. The model for the project was based on the German Market Incentive program but adapted to the Mexican context (BMUB, 2015). The project developed a special loan for the purchase of SWH under this initiative, using the Hipoteca Verde program combined with a grant from foreign funds (GIZ) (Mata & Ortega, 2015).

The collaboration of the CONUEE with the GIZ for the PV sector started in 2009 with the study *Market niches for the use of photovoltaic panels in connection to the electrical grid in Mexico* (Amtmann, 2009). The results showed that the subsidies to electricity were a barrier to the development of the sector. However, it also showed that besides the subsidies, the photovoltaic industry was going to become financially viable for the residential middle-high sector and for the commercial sector (Amtmann, 2009). This led to a new project focused on photovoltaic panels for these sectors. The project, called PROSOLAR and launched at 2012 was implemented by the SENER and the GIZ and was intended to develop the market and the local solar photovoltaic industry in a short and mid-term by guaranteeing the quality of the equipment and associated services, development of a regulatory and normative framework, finance mechanisms, capacitation programs (for associated services and producers) and diffusion of information to the general public (SENER & GIZ, 2012).

It is important to highlight how the success of the PROCALSOL project derived (regional branching) in the implementation of similar strategies for the PV industry, the PROSOLAR project. It follows the same route, first a study to understand the PV market and then several strategies intended to mobilize necessary resources for the development of a sector. This shows the key role that similarities between technological characteristics can play an important role in policy design and resource mobilization. In this case the successful finance, market and legitimacy mechanism used in the SWH sector and the knowledge to implement them were taken and applied on the PV sector These spillovers are shown in Figure 3 with arrows.

By 2008 a period of legal reforms started, the Law for the Sustainable Use of Energy (LASE) and the Law for the use of renewable energies and finance of the energy transition (LAERFTE) were developed with the aim to foster the development of the renewable energies industry in Mexico, increase of the energetic portfolio of the country and expand the electric service in rural communities (Gobierno de la República Mexicana, 2009). These laws derived in an important number of national programs and strategies to promote renewable energies, the ENTEASE, FOTEASE, PEAER, PROSENER among others. These strategies promoted the obtention of local and extra-regional extra- resources, the most common extra-regional resource is knowledge, followed by finance, meanwhile market and legitimacy were promoted in the local context. In addition to this programs and laws, the environmental sector in Mexico - by 2012 - urged to reduce the emissions of the energy sector through publishing the General Law of Climate Change (LCC).

Resource	Type of policy	Origin of resource	Sector impacted
Knowledge	- Actors	- Extra-regional - Local.	- Renewable energies
	- National initiative	- Local - Mixed	- Renewable energies - SWH - PV
	- International initiative	- Mixed	- SWH - PV
Market	- Actors	- Extra-regional - Local	- Renewable energies
	- National initiative	- Local - Mixed	- Renewable energies - SWH - PV
	- International initiative	- Mixed	- SWH - PV
	- Regulation	- Local - Mixed	- SWH - PV
Finance	- Actors	- Extra-regional - Local	- Renewable energies
	- National initiatives	- Local - Mixed	- Renewable energies - SWH - PV
	- International initiatives	- Mixed	- SWH - PV
Legitimacy	- Actors	- Local - Extra-regional	- Renewable energies
	- National initiatives	- Local - Mixed	- Renewable energies - SWH - PV
	- International initiatives	- Mixed	- SWH - PV
	- Regulation	- Local - Mixed	- SWH - PV

Table 6: Resource mobilization summary, second period.

This period is where SWH technology was accepted and consolidated in the country. As Figure 3 shows, a lot of efforts were placed in the legitimization of the technology and in developing finance and markets mechanisms to promote the sector. Furthermore, knowledge was developed locally and catch-up through the collaboration with the GIZ. These events were promoted by the PROCALSOL project, which is considered a very important project that had a great impact on the development of the SWH sector. In addition to that, this period is also considered as the start for the PV industry, since regulatory reforms were made that enable the sector to start a real development.

Table 6 summarizes the type of policies and mobilization of resources that took place during the second period. As it can be seen the resource market and legitimacy are very active

5.3. 2013 – 2018: Energy reform

At the end of the year 2013, the energy reform took place, this changed the legal framework of renewable energies and impact on both SWH and PV sectors. by transforming the energy producing sector into a possible private business, which increased the demand for PV systems. That is why this period is transcendental for the solar industry. Nevertheless, due to the regulatory adaptation to the new frameworks required, no important advances are seen from 2013 until today because some years are required for adaptation processes to occur.

Because of the energy reform, two new programs were developed or updated. One of the most important was the national program for the sustainable use of the energy (PRONASE) developed by the SENER with the aim to establish the objectives, targets, strategies and actions that enables the country to achieve efficient use of energy in every process of the energetic chain through the increase in the utilization of clean and renewable energy sources, while promoting social and environmental responsibility; and the strategic program for human resource formation in relation to energy (PEFRHME), that aims to form talent that supports the development of the energy sector. It will close the gap between the offer and demand of capable specialist in the energy sector (SENER, SEP, & CONACYT, 2014).

During 2015, a new legal framework, pushed by the energy reform was developed. The LASE and LAERFTE laws were replaced by the Energy Transitions Law (LTE), its main objective is to regulate the sustainable use of energy, the obligations in relation to clean energy and pollutant reduction of the electric industry and securing the competitivity of the productive sectors. The objectives of the law are enforced through the Transition Strategy to Promote the use of cleaner technologies and fuels and by the special program for the energy transition (ETPUTCL), which was published during 2016 and has the aims to establish targets for renewable energies, promote the reduction of pollutant emissions of the electric industry and reduce the dependency of fossil fuels as a main energy source.

Last, but not least, during 2016 the SENER published the strategic program for the energy transition (PETE) which is aligned to the objectives of the ETPUTCL and has the aim to achieve the objectives of the LTE. As can be seen in Figure 3, this period is highlighted by national initiatives like programs and strategies that were derived from the energy reform. It is important to mention that the DKTI project is another collaboration with the GIZ for PV sector, but directed towards big energy generators. This is the first program derived from the energy reforms that seek to increase PV mass energy generation in the country. It is included because it is considered that it impacts the development of PV industry.

Given these points, the third period is characterized by the adaptation process of the policies to the new regulatory framework derived from the energy reform. The main strategies to promote resources are national initiatives that promote local and mixed resources, some of them are old initiatives that needed to be updated due to the energy reform. The sector that is more promoted during this phase are renewable energies in general and photovoltaic sector. Table 7 summarizes the resources mobilized and the strategies for its mobilization.

Resource	Type of policy	Origin of resource	Sector impacted
Knowledge	- Actor	- Local	- Renewable energies
	- National initiative	- Local - Mixed	- Renewable energies
	- International initiative	- Mixed	- PV
Market	- National initiative	- Local - Mixed	- Renewable energies
	- International initiative	- Mixed	- PV
	- Regulation	- Mixed	- SWH
Finance	- Actors	- Mixed - Extra-regional	- Renewable energies
	- National initiative	- Local - Mixed	- Renewable energies
	- International initiative	- Mixed	- PV
Legitimacy	- National initiative	- Local	- Renewable energies
	- Regulation	- Mixed	- SWH

Table 7: Resource mobilization summary, third period.

6. DISCUSSION

This chapter discusses the policies identified in the last section towards the understanding of how the specific resources are promoted. The aim is to understand the type of resource promoted and the role that the characteristics of the technology play for new path development, considering if resource obtention is promoted through extra-regional linkages or through regional branching or other local innovation processes. Section 6.1 discusses in detail how each resource is mobilized and the role of the characteristics of the technology for its mobilization. It is divided in 4 section, each one per resource. A summary (Table 8) is included at the end of the section that describes the main implications of the technological characteristics for the policy approach promoted.

6.1. Resource mobilization promoted

i. Knowledge

Knowledge is considered as the most important resource for an early stage of industrial development (Bergek et al., 2008; Binz et al., 2016), its usage, importation, combination, and recombination delivers innovation from where new paths can emerge. It is mobilized through the promotion of research and development (R&D), support for the translation of a new product to manufacturing and support for entrepreneurial experimentation and importation of equipment (Binz et al., 2017).

Knowledge mobilization for the period analyzed followed the same path for both technologies. At the beginning, international knowledge could not be adopted due to the incompatibility of it to local circumstances (Tonatiuh and Sonntlan unsuccessful projects, see Figure 3). In order to make the adoption of external knowledge possible, was first necessary to develop a solid base of local knowledge that could handle and catch-up knowledge from the outside. That is why the largest mobilization of local knowledge is at the beginning of the period (see Figure 3). Actors played a key role for this process. They mobilized knowledge through local innovation processes, especially through the promotion of R&D activities for both sectors.

After the development of local knowledge, extra-regional resources appear and gained importance. Extra-regional knowledge was promoted through cooperation projects between Mexican and international agencies (PROCALSOL and PROSOLAR). The CONUEE, on the Mexican side, and the GIZ, on the international side played a key role for knowledge obtention for the development of both sectors (see Figure 3).

The impact that the degree of complexity of product architecture has on the approaches promoted to obtain knowledge depend on the stage of development of the sector. The first steps of the development of both industries, regardless of the degree of complexity of product architecture- were done considering only local innovation processes and local knowledge resources. However, the consolidation of both sectors was achieved in different forms. The industrial consolidation of SWH was done with local resources, while PV required the integration of extra-regional knowledge. This is explained by the higher rate of Mexican SWH's companies in comparison to PV systems (Table 3 and Table 4). It is important to mention that this extra-regional knowledge wouldn't be able to be introduced without the local knowledge formed previously. For both sectors, the knowledge promoted was related to improve R&D capacities and increasing capacitation and training for professionals and technicians. This shows the importance of the adaptation of extra-regional resources to local context, which is the essence of catching-up processes. Given these points, it can be said that, on one hand, the policy approach to promote higher complexity products is two-folded, first through local innovation processes to form a solid knowledge base, and secondly through extra-regional linkages to catch-up special knowledge required for industrial consolidation. On the other hand, less complex products can be promoted through local innovation processes.

The role that the similar scale of production process has for the policy approaches promoted takes place by the implementation of policies. The regional branching processes between the projects PROCALSOL and PROSOLAR are good to exemplify this (see Figure 3). The success in the PROCALSOL project was replicated by the PROSOLAR and the knowledge generated was transferred from one to the other. These projects were focused in increasing the use of both technologies in the housing sector, the knowledge required for these processes is almost the same for both technologies because it entails the knowledge required to market and diffuse the technologies, which is similar for both.

The technological characteristics have a direct impact on the approach that policies promote to mobilize knowledge. On one hand the differences impact on the origin of resource promoted along time, at the beginning resource promotion is local but afterward it becomes extra-regional, especially for more complex products. On the other hand, the similarities have an impact on the side of the know-how of policy implementation and diffusion of the technology in the housing sector.

ii. Market

Markets are considered a critical resource because it is the enabler of the industry, if no market exists, the industry actors cannot buy and sell (Binz et al., 2016), and its development is impossible. Consequently, markets are one of the first things that are constructed when an industry is emerging. Efforts to develop a market for solar industry are observed since the beginning of the period analyzed, however, it came later than knowledge. The typical strategy to promote the development of markets is two-folded, on one side it considers the promotion of domestic mass markets and economies of scale, meanwhile on the other side considers the promotion of export markets (Binz et al., 2017). This analysis is based on the development of both industries for the housing sector, that is why only activities related to the development of domestic markets were identified

The similar scale of production process between SWH and PV sector have a special role in market resource development because the market structure is the same for both industries, and especially for the housing sector. SWH's and PV systems are sold in retails stores, brought to a house and installed by a technician. This similarity derived in the utilization of the same approach to promote mass markets. The promotion was done through the initiatives PROCALSOL and PROSOLAR and considering catching-up processes, these were collaboration projects that promoted domestic markets considering extra-regional experiences and merging them with local ones. Due to the similarities of the technology, spillovers between both are observed, successful market mechanisms developed for PROCALSOL were used afterward for PROSOLAR, using the same financial mechanisms and models. Moreover the market infrastructure (retailers store, installing service, etc.) used by the SWH industry is used also for the PV one (See arrows in Figure 3).

The promotion of markets through standards, norms and capacity building processes for installers are also important mechanisms since these ensure quality and confidence in the technology. These appear first for the SWH sector, from 2005 onwards. The regulation for the PV systems appears at 2011 in forms of eight norms. The markets of both technologies were benefited from the standard development. National and international initiatives played a key role in these processes (see Figure 3) by implementing catching-up policies that promoted mixed resources. A link between these initiatives and the standards exist since one of the aims of these is the promotion of standard development.

The differences between SWH and PV in relation to the market resource are few. Market resource mostly affects the scale of production process and not the complexity of product architecture, which is what is different between the technologies. Still, some important differences exist that affected the approaches considered for resource promotion. The main difference is the regulatory framework, which played special role in the approach for resource mobilization. Regulatory framework is inherent to the local context, hence the market resource promoted in relation to this topic was developed locally (see interconnection contract in Figure 3) and was very helpful to increase demand of PV systems. This resource was the unique market resource promoted totally through local processes.

The impact of the technological characteristics for policy design towards market resource mobilization is higher for the similar scale of production process in comparison to the different degree of complexity of product architecture. The technological characteristics have a direct impact on the approach that policies promote to mobilize market resources. For the case analyzed, the approach to mobilize market resource and consolidate a well-functioning market considered catching-up policies, and international experiences adapted to the local context. Once established, these market resources were transferred through regional branching processes between products with similar scale of production processes that required the same market structure. Some specificities can arise in relation to the higher complexity of product architecture that requires the mobilization of specific resources to increase market. These specificities, for the sector analyzed, are related to local contexts, and must be mobilized locally.

iii. Finance

Finance is considered as a key resource that usually is scarce at the early stages of development, it is often mobilized by angel investors, investors, commercial banks (Binz et al., 2016), state government and multilateral and bilateral cooperation agencies. Two main lines of finance resource are promoted, the first one is the provision of low cost-loans for acquisition of equipment for the end-user, and the second one is the creation of a venture capital systems (Binz & Truffer, 2017).

The strategies through which policies mobilize finance are several, the first cases, at the beginning of the process, where made by the ANES, through the obtention of funds of multilateral agencies. After that, no finance was mobilized until later, when the Green Mortgage model was developed locally, and improved by international initiatives, which mobilized finance for both end-users and venture capital systems (see Figure 3).

The role of the similar scale of production process in the approach promoted by policies depend on the type of finance mobilized. Finance for end-users was initially mobilized locally through the Green Mortgage, which is a finance program for end-users of the low-income sector. At an initial stage, the resources for this program were focused on SWH and the origin of the resources were local. Afterward, due to the successful results, the program was expanded to the PV sector and extra-regional resources were injected to provide more loans. Multilateral agencies played a key role during this process, especially to build capacities on private entities for the development of commercial loans for SWH and PV systems for the end-user.

The role of the different complexity of product architecture on the approaches considered to promote finance resource mobilization is linked with the second type of financial resource promoted, the venture capital system. A venture capital system is finance for potential emerging firms. In comparison to the end-user finance described before, these are risky investments, which require higher quantities and are usually intended to increase production processes. It's important to note that venture capital systems usually appear at the very early stage of industrial development, this explains why this type of financial resource were directed to PV Industries. On one hand, SWH industry was able to satisfy the demand of its products in the country, hence finance for it was mobilized towards facilitating the acquisition for the end—user. On the other hand, the PV technology production capacities were low, hence finance was promoted to be mobilized towards increasing the production capacity. Afterward, models to finance end-users were adapted to PV industry, considering both, the insight developed previously for the SWH sector and international experiences.

Catching-up policies played a major role in relation to the financial support developed to increase production capacities in the country, which has primarily been promoted through international initiatives and national programs and strategies. One of the interesting insights of the analysis is that the finance for end-users is mainly locally mobilized, meanwhile the finance for companies and to increase production is mostly catch-up from the international arena. Nevertheless, it is important to mention that mobilization of local financial resources for the production side also exists, but in a minor degree. Additionally, the policies analyzed show the absence of specific finance spillovers between SWH and PV sector for increasing production capacity. The electronic and semiconductors industry is the one that seems to provide finance spillovers for the PV industry, at the end PV systems are electronic devices and is more feasible for an electronics company to invest in such a technology than for a thermal one.

The implications for policy design in relation to finance depend on the type of financial resource promoted. Lower financial resources, like finance for end-users are usually promoted at the domestic level and developed with local resources and can be transferred from one industry to the other, regardless of the different degree of complexity of product architecture. On the contrary, higher financial resources like venture capital systems are promoted through catching-up processes, transfer of these resources between both industries is not feasible due to the different higher complexity of product architecture and the core technology of industries, electronic for PV and thermal for SWH.

iv. Legitimacy

Legitimacy is the tool in which skepticism and user acceptance are conceived, it is reached through the adaptation of the innovation to the institutional context or the other way around, moving the institutional context so that these fit to the innovations (Binz et al., 2016). It is achieved by the adoption of quality certification and standard systems and the mobilization of policy and public support with success stories (Binz et al., 2017).

The promotion of legitimization for the development of SHW and PV industries in Mexico has been done following two strategies, the first one considers the legitimization on the user side, the user acceptance that the product is good and will deliver them benefits, while the other is the legitimization about the capacities of the country to produce quality solar energy artifacts.

The similar scale of production process between both technologies is related to the legitimization on the user side, the policy approaches to promote this were promoted through regulations, adoption of standards and demonstration projects. Standards and regulations consider that due to certifications the user will be motivated to acquire solar energy artifacts. However, this is not enough, this must go hand in hand with demonstration projects that show how solar energy artifacts work. This kind of projects was one of the principal ways in which legitimacy was promoted and has been considered through the whole process for both sectors. This kind of legitimization started for SWH with the PROCALSOL project and then was derived to the PV industry through spillovers, the project PROSOLAR played a key role in this respect.

Legitimacy spillovers between technologies are observable for user acceptance, in this sense, the characteristics of the technology plays an important role, however these spillovers are not enough to legitimize more complex technologies. On one hand, the user accepts, that if harnessing solar energy works on SWH it will also work for PV, however, due the higher level of complexity of such a system, the acceptance is not that easy transferred. Consequently, two different lines of legitimacy, with important spillovers between them, were promoted. The interesting outcome is that PV legitimacy is much more promoted through transnational linkages than SWH.

National actors, especially new organizations formed at the beginning of the period (see Figure 3) were key player to promote legitimacy, the main objective of this organizations was to promote regulation and diffusion of information. At the beginning its efforts were done totally with national resources and for SWH sector. Afterward, these organizations started joint ventures with international actors to keep promoting legitimacy in SWH and include the PV industry. Again, like for the other resources, the PROCALSOL and PROSOLAR projects are key actors for legitimacy promotion.

The higher complexity of product architecture between both technologies has a direct impact on the legitimization about the production capacities of the country. As mentioned before, the foundations of SWH and PV systems are different (electronic vs. thermal). That is why legitimacy to prove that the country can produce good quality artifacts for both technologies comes from different origins. Standard design and adoption has an important role in this regard, although these does impact the end-user decision, its fulfillment depend on the complexity of product architecture.

On one hand, the legitimacy that the country could produce SWH took place at the beginning of the process and was promoted from local resources. The simplicity of a SWH made this process possible without external inputs, however the consolidation of standards development did include extra-regional resources. On the other hand, the legitimacy about the production of PV systems took more time to start, but when it started it was faster. It developed eight norms at the same time. The faster velocity is a consequence of the higher complexity in product architecture. Complex and electronic products must be highly regulated to appear on the market. This process required the implementation of catching-up policies for acquisition of extra-regional knowledge and adoption to local situation. Although the standard development process was based on extra-regional resources, the legitimization process of the production capacities of SWH and PV systems started with local resources (Table 3 and Table 4).

It is also important to mention that the local resources used for standard development to confirm local PV production capacities came from the electronics sector and not from the thermal one. The company ERDM and IUSA exemplified this (Table 4), the latter was a consolidated Mexican company of electronic devices that started the production and, consequently the legitimization of the Mexican capacities process, meanwhile the extra-regional resources came to the country through foreign manufacturing companies, also from the electronic sector. After a while, the legitimacy on the country was achieved and other companies, both local and foreign, started to appear.

Legitimacy in relation to both sectors in Mexico consider the user acceptance and the local production capacities. The user acceptance depends on the scale of production process, that is why it follows the same strategy for both technologies which is mainly done locally. The local production capacities are related to the higher complexity of product architecture and is achieved through standard development. Both (high and low complexity products) require the development of standards with international inputs, nevertheless the low complex products can start this process with local resource, while the more complex ones require extra-regional resources since the beginning

Resource	Role of technology characteristics for policy approach	
	Different complexity of product architecture	Scale of production process
Knowledge	- Regardless of the degree of complexity, local innovation processes are required at initial stages. - Higher complexity industries require extra-regional knowledge for consolidation. - Lower complexity industries can be consolidated with local knowledge resources.	- Knowledge required for policy implementation and technology diffusion can be obtained locally.
Market	- Higher complexity products can have different regulatory framework, must be done locally.	- Formation of well-functioning markets its easier through catching-up policies. - Well-functioning markets can be transferred between sectors and can be done locally.
Finance	- Higher complexity entails higher costs and investments. - At the beginning extra-regional resources are mobilized for venture capital systems. - When consolidation achieved, local innovation processes developed end-users loans.	- Similar models of loans for end-users are required. - Can be developed locally and transferred between technologies.
Legitimacy	- Higher complexity requires combination of local and extra regional efforts for standard development throughout the whole process. - Low complexity might not totally require extra-regional inputs	- Approaches to promote end user acceptance are local. - Transfer between technologies is feasible

Table 8: Implications of technological characteristics for policy approach promoted

6.2. Considerations for policy design

The analysis derived some important consideration worth to be mentioned. The first one is about the type of policies that promotes resource mobilization, which are mostly national and international initiatives combined. The combination of efforts to mobilize resources is the essence of catching-up policies which consist in anchoring external resources through aligning processes in which stakeholders from both sides must cooperate (Binz et al., 2016; Crevoisier & Jeannerat, 2009). Considering this, the two projects that were delivered only with extra-regional knowledge stand out, due to their unsuccessful results, empowering the necessity of catching-up processes to anchor resources. However, the type of policy, stakeholders, and interaction among them depends on the stage of development of the sector. At the very begging the resource mobilization was promoted only through national actors and national initiatives (the international projects were unsuccessful during this time). Afterwards, international initiatives and actors took an important role on the resource promotion process (Figure 3). This observation leads us to consider that even during an early industrial phase can different periods be identified and that these periods requires the action of different stakeholders and different kind of policies.

The considerations of the previous paragraph lead us to question the possibility of implementing catching-up policies at the very beginning of an industrial process due to the lack of local resources able to handle extra-regional ones. As mentioned before, the only two projects that were totally extra-regional were unsuccessful. After this, no other hundred percent extra-regional project was executed, instead only successful collaborative projects took place. This observation is important, as it appears that related local resources are required to anchor external resources. This must be considered for developing and emerging economies because -if it is true- these cannot totally rely on extra-regional innovation process to develop new paths. However, some local development of resources must preexist to be able to catch-up those coming from the outside. To sum up, there is a necessity of local innovation processes to handle external innovations and resources and anchor them to the local context.

Another important consideration from the analysis is related to regional branching processes. Figure 3 shows with arrows how regional branching processes took place between SWH and PV. The successful PROCALSOL project mobilized resources that were afterward used by the PROSOLAR project. However, it's important to clarify which are the types of resources that were mobilized from one sector to the other. Figure 3 shows that knowledge, market, finance, and legitimacy was mobilized, however, it does not say that these resources were principally related to the introduction of the technology in the country and not to the technology by itself. To put it differently, the resources transferred from SWH to PV were related to establishing a market, legitimizing the technology and developing financial mechanisms for end-users, the knowledge transferred was related to the know-how to establish these mechanisms. No resource was mobilized from SWH to PV to improve production or to promote innovation of the products. This kind of resources came from extra-regional resources or, if locally, from the electronic industry. This observation is important because it answers part of the question about the implications of the characteristics of the technology for resource development. Apparently, the characteristics of the technology define which resources can be obtained from one source and which from the other. This is an important implication for local innovation and catching-up policies design since these should be done considering the different characteristics of the technology and the possible resource origin for its development.

7. CONCLUSION

This thesis research aimed to analyze the policies enforced in Mexico from 1980's to 2018 to promote resource mobilization for the development of the SWH and PV industries. The main inquiry was to understand the kind of policies that promote this and the role of the characteristics of the technology for the design of the policies, especially for understanding if policies aimed to develop the resources locally or aimed to obtain resources from extra-regional locations through catching-up policies.

The analysis showed that along the period analyzed resource obtention has been promoted in several ways. At the beginning of the process resource obtention was done locally and promoted by research centers, NGO's and the private sector. Afterward, the state started promotion through a variety of policies that seek to obtain the resources implicated, this part of the process started with local resources and later included extra-regional through collaboration initiatives. The international collaboration has been critical for the development of the sectors. The analysis delivered insights that are worth to mention.

The first insight is the importance of the local, the analysis suggests that catching-up policies were only able to anchor extra-regional resources when enough and mature local resources related to the topic in question existed. These local resources had the capacity to deal and adopt extra-regional resources and to use it for the development of the sectors. This shows the importance of the local development of resources and puts the simple importation of extra-regional resources in question; catching-up processes must consider the local circumstances to adapt and mobilize extra-regional resources.

Another important insight is related to the characteristics of the technology for regional branching processes. The analysis showed that resources were transferred from the SWH to the PV, but only those resources where technologies are compatible were transferred. Although these technologies harness the energy of the sun, their technological background is different and requires a different kind of knowledge. Which is why the PV industry shows more linkages with the electronics industry than to the SWH one. This result shows the importance of combine and recombine knowledge from several industries and sources, a diverse environment of industries must preexist to deliver new paths. This might be one of the reasons of the lack of new paths in emerging economies and developing countries, the homogeneous industrial sectors cannot easily evolve into new paths.

The finding of this research can help to gain a better understanding of the role of the characteristics of the technologies for the policy approach promoted. It is observed that the mobilization of each resource must be done considering specific characteristics of the technologies. On one hand, resources related to a similar scale of production processes can be approached through local innovation processes and considering experiences from other sectors (regional branching). On the other hand, resources that are related to the complexity of product architecture are usually approached through transnational linkages, due to the higher complexity of resources required to promote the development of this industries and the different fundamental concepts embedded in them. Given these points, it must be noted that catching-up approaches, that considers local and extra-regional origins, seems to be the best approach to promote a quick resource obtention for both types of technologies.

In relation to the context of emerging economies and developing countries. The analysis suggest that new path development in these contexts must consider catching-up processes, but emphasis must be placed on the processes to adopt and anchor extra-regional resources to the local context. The major weakness of catching-up policies is the lack of consideration of local context and the arrangements to make the adoption of the extra-regional knowledge possible. Both types of technologies analyzed showed that local resources set the ground -at the very early phase of development- to adopt later extra-regional resources.

Considering this, and the current urgency to transit towards low carbon economies through sustainable transitions. It can be argued that the best recipe for sustainable transitions in emerging economies is through a combination of local innovation processes and catching-up policies. Special considerations to understand the local context must be done in order to successfully anchor extra-regional resources to the local context.

These insights must consider the limitations of the thesis. First, the analysis considered only a desktop policy research, which can be biased by the researcher due to their interest in the topic. Furthermore, no knowledge about real results of the policies was considered which could have helped to draw a better understanding of the mobilization of resources. Secondly, the analysis only considered policies and not stakeholders for new path development. Their role (e.g. lobbying) is very important, especially at the early stage of development. Therefore, the absence of a critical analysis of their implications is considered as an important limitation of this thesis. Finally, one last limitation is regarding the focus of the analysis on the housing sector, it is considered that in other sectors results might have been different. One example is the industrial sector in which both technologies could be used, but with different objectives. This would change the market structure and, henceforth, different outcomes might have arisen.

As a concluding remark from the perspective of the researcher. From my personal experience, I consider that the combination of extra-regional and local resources is necessary for the development of a sector, although the characteristics of the technology do play a role. A sector will always be better developed if a combination of resources from different sources coexists. For the case of emerging economies like Mexico, the relevance of this increases, since the country has innovation and industrial capacities at some sector and regions and not for others, which contributed to an unequal development of the country. However, mixing successfully local and extra-regional resources do not only depends on the innovation capacities or local knowledge of a region, other factors like security, education, poverty, etc. must be considered, especially because these are the biggest issues that hinder new path development in emerging economies. Further research needs to consider how the mixture of local with extra-regional resources can help towards developing new paths towards alleviating these important problems of emerging economies.

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9. APPENDIX

Appendix 1: Policy biography

Period	Typology	Policy name and description
1975	Law	*Electric Power Public Service Law (LSPEE)* - Market: Mexican central government, only entity allowed to produce and manage energy
1974 - 1975	International Initiative	*Tonatiuh project (French technology transfer project)* Installation of 14 solar pumping plants that also produce energy in remote and arid areas. Unsuccessful project. - Knowledge: Failed attempt to import extra-regional knowledge
1976	Actor	*Creation of Non- conventional energy sources department at the Institute for electrical research (IIE)* - Knowledge: research and development for solar energies
From 1977	National Initiative	*First National meeting for Non-conventional energies* - Knowledge: Exchange and combination of knowledge between stakeholders. These meetings are being still held, yearly.
1978	International Initiative	*Sonntlan project (German technology transfer project)* Development of a coastal desert fisherman's community through solar energy. Unsuccessful project - Knowledge: Failed attempt to import extra-regional knowledge
1978 - 1980	National Initiative	*Pilot production line for solar cells in Polytechnic University in alliance with the CINVESTAV* - Knowledge: Acquisition of experience in solar cell production and research and development promotion - Legitimacy: Demonstration of the existence of technical capacities in the country for PV systems production
1980	Actor	*National Association for Solar Energy (ANES) was founded.* - Knowledge: diffusion of knowledge through information exchange, unity and cooperation between members. - Market: Promotion of standards development for quality - Finance: Mobilization of national and international finance por improving production processes. - Legitimacy: Promotion of benefits of solar energy and demonstrative projects
1986	Actor	*Creation of the Center for Energy Research (CIE)* Center for energy research with a specialized department for solar energy - Knowledge: Research, development and innovation in solar energy
1989	Actor	*Creation of the National Commission for Energy Saving (CONAE)* A national entity created to promote renewable energies. - Market: Promotion of standards development - Legitimacy: Promoted renewable energies, its divulgation, promotion, and development.
1980 - 1990s	National Initiative	*Several projects for the rural electrification all over the country* The inclusion of PV and SWH energy as the backbone of these projects - Knowledge: better understanding of solar technologies, especially PV systems. - Legitimacy: Demonstrative projects of the benefits of solar energy.
1992	Law	*Electric Power Public Service Law (LSPEE)*

Period	Typology	Policy name and description
		Allowance to private entities to produce energy for self-consume. - Market: Promotion of PV systems acquisition by increasing benefits of its usage
1995	Actor	*Creation of the CRE* Energy regulation commission - Market: Aims to regulate the energy market
1996	Actor	*Creation of the COFER* Council for the promotion of renewable energies in Mexico - Market: Aims to promote and strength of the relation between the agents involved in the market of renewable energies in Mexico
2001	Regulation	*Model of contract for connection between a private power generator and the national energy grid* - Market: Promotion of PV systems acquisition by increasing benefits of its usage
2004	National Initiative	*Income tax law* Tax exemption for acquisition of renewable energies equipment - Market: Promotion of domestic market of PV systems
2005	Regulation	*NMX-ES-001-NORMEX-2005*. Development of a national standard for test methods for thermal performance and functionality characteristics of SWH. - Market: Boost market by increasing reliability on SWH equipment - Legitimacy: Increase legitimacy by developing quality standards
2006	International Initiative	*Financial alternatives for promoting the use of solar water heaters (SWH) in the Mexican domestic sector*. Study to identify a best financial mechanism for SWH, collaboration project by ANES, GIZ, and SENER - Knowledge: Better information about the alternatives for SWH's
2006	Regulation	*NADF-008-AMBT-2005*. 30% of solar warm water per new building and regulation of minimal quality standards for SWH - Market: Boost market by increasing reliability on SWH equipment and force its purchasing by end-users - Legitimacy: Increased legitimacy by developing quality standards
2007	National Initiative	*Model of contract that allows the low scale producer (below 30 MW) to connect to the National Electric System.* - Market: Promotion of PV systems acquisition by increasing benefits of its usage
2007	International Initiative	*PROCALSOL* *Program for the promotion of Solar Water Heaters, promoted by the GIZ, CONUEE and ANES.* - *Knowledge:* Support to increase formation and capacitation of well-capacitated technicians and installers of SWH and Promotion of seminars in exchange of offer and demands of technological development. - *Market:* Increase the offer of well-capacitated technicians for installation of SWH, Implementation of generalized interest rates and financial scheme to reduces the initial cost of acquiring SWH, and Implementation of mortgage for buying SWH in new houses (Green Mortgage). - Financial: Financial support to SMEs dedicated to build, sell and install SWH and to end-users through the Green Mortgage

Period	Typology	Policy name and description
		- Legitimacy: Promotion of norm development and regulatory instruments for systems and installations, Certification of design, installation, operation and maintenance companies, establish a quality seal for equipment, Realization of pilot and demonstrative projects in the public, social, commercial and industrial sector, campaign to raise awareness about the benefits of SWH for the population, and website with information about benefits of solar energy
2007	National Initiative	*Hipoteca Verde (Green Mortgage)* Loan program that grants an extra amount of money as part of the housing mortgage for SWH. - Market: Booster of the market through facilitating the access for SWH's - Finance: Financial support to end-users to get SWH's
2007	Regulation	*NMX-ES-002-NORMEX 2007*. Definitions and terminology. - Market: Boost market by increasing reliability on SWH equipment - Legitimacy: Increased legitimacy by developing quality standards
		NMX-ES-003-NORMEX 2007. Minimal requirements for the installation of solar thermal water heating systems. - Market: Boost market by increasing reliability on SWH equipment - Legitimacy: Increased legitimacy by developing quality standards
		NMX-ES-004-NORMEX 2007. Thermal evaluation for solar water heating systems. Test method. - Market: Boost market by increasing reliability on SWH equipment - Legitimacy: Increased legitimacy by developing quality standards
2008	International Initiative	*Transformation and strengthening of the Solar Water Heating market initiative (ITFMCSA)* - Knowledge: Capacity building of local SWH manufacturers, distributors, installers, and financing sector to offer products, delivery models (including financing), installation, after sale and financial services that are conducive to overall market transformation goals of the project, enhancing capacity of the supply chain to offer products and services promoting a sustainable SWH market - Market: Enabling legal and regulatory framework to promote a sustainable SWH market, increase demand for SWH systems based on the availability of attractive end-user financing mechanism, development of different direct or indirect financial and fiscal incentives to promote a sustainable SWH market, enhancing capacity of the supply chain to offer products promoting a sustainable SWH market - Finance: Improving the incentives such as commercial soft loans with government support, capacity building of the capacity of local SWH financing sector to offer products and financial delivery models - Legitimacy: Enhanced awareness and capacity of the targeted end-users, housing developers, and other key stakeholders to facilitate the integration of SWH into new housing developments and into other promising new market segments (information), recognition of SWH installers through the development of a standard (set of criteria) to demonstrate their know-how and to the best projects.,

Period	Typology	Policy name and description
		development of an effective and affordable certification and quality control scheme applicable for all SWH systems manufactures and/or installed in Mexico, campaigns to raise awareness for end-users on the benefits, economic feasibility and other characteristics
2008	Regulation	*Technical Standard of Labor Competence for the installation of Solar Water Heating systems EC065* Standard for evaluation and certification of installers of SWH. - Legitimacy: Increased legitimacy by developing quality standards.
2008	Law	*Law for the Use of Renewable Energies and the Finance of the Energy Transition (LAERFTE)* - Knowledge: Support the promotion and use of scientific research and technology for renewable energy, propose the creation of funds and trusts with the aim to support promote the use of scientific and technological research in matters of renewable energy. - Market: Establishment of a normalization program for energy efficiency - Finance: propose the creation of funds and trusts with the aim to support technological research in matters of renewable energy. - Legitimacy: Establish a normalization program for energy efficiency, procure the necessary measures for access to reliable and appropriate information in relation to energy consumption of the equipment, devices, and vehicles
2008	International Initiative	*National Strategy for the Energy Transition and Sustainable Use of Energy (ENTEASE)* - Knowledge: Promote programs for the formation of high-level professionals in the national and international arena - Market: Development of norm and standards to secure quality and boost the market. - Finance: Establish support programs for the low-income sector to acquire energy efficient technologies. - Legitimacy: Design diffusion programs to accelerate the adoption if efficient technologies and best practices.
2008	Law	*Law for the Use of Renewable Energy (LASE)* - Knowledge: promotion of the scientific and technological research for the sustainable use of energy, include in the study programs of the basic, middle and middle-high education topics about the sustainable use of energy, promote the formation of specialists in the use of renewable energies, in the superior level. - Legitimacy: Establish a normalization program for the energy efficiency and allow access to people to reliable and effective information about energetic consume of equipment, devices, and vehicles, among others
2008	Actor	*Commission for the Efficient Use of Energy (CONUEE)* The CONAE evolves towards CONUEE - Market: promotions of actions for energy efficiency and energy saving, which improves the market. - Legitimacy: diffuse information about renewable energies

Period	Typology	Policy name and description
2008, 2014 (new version)	National Initiative	*National Program for the Sustainable Use of Energy (PRONASE)* - Knowledge: Increase capacity building for design, implantation, and operation of projects related to energy efficiency and renewable energies, promote research and technological development for energy efficiency, promote and support the collaboration and knowledge exchange between national and international institutions for energy efficiency, promote the formation of human resources dedicated to technological, economic, environmental and social energy-related research, and promote the use of the sectoral funds for energy-related research. - Market: Strengthening of the regulation for energy consuming devices and systems produced in the country, Strengthen and increase the offer of consultancy and project development companies - Finance: Promote the utilization of sectorial funds for the technological, environmental, economic and social investment in relation to the energy reform - Legitimacy: Disseminate information about the sustainable use of energy, design orientation campaigns related to the sustainable use of energy, establish collaboration agreements with public, private and social organizations to disseminate information about the sustainable use of energy, and promote the inclusion of topics related to the sustainable use of energy in the low, middle and middle-high education
2008	National Initiative	*CONACYT – SENER sectorial fund for Sustainable energy (FSE)* - Knowledge: Finance of research projects for sustainable energy and promote the formation of highly qualified specialists
2009 (2016,2017)	National initiative	*Fund for the Energy Transition and Sustainable Use of Energy (FOTEASE)* - Knowledge: Finance of projects for sustainable energy - Finance: Mobilization of resources for renewable energy sector development.
2009	International initiative	*25,000 solar roofs for Mexico* - Knowledge: Establish capacitation programs to increase the knowledge related to installation and maintenance of SWH. - Market: Strengthen the Mexican production capacity and services, establish capacitation program to increase the knowledge related to installation and maintenance of SWH, development of a mortgage facility combining the already existing "Hipoteca Verde" with a grant of foreign funds. - Legitimacy: Raise awareness among clients and institutions about the benefits of the technology and finance options, diffusion strategy for the residential sector
2009	International initiative	*Market niches for grid-connected photovoltaic systems in Mexico* Document that studies the market niches for grid-connected photovoltaic systems in Mexico, done by SENER, CONUEE, and support from the German GIZ. - Knowledge: Better information about the alternatives for SWH's
2009	National Initiative	*Special Program for the Use of Renewable Energies (PEAER)* - Knowledge: promote capacity building in relation to solar energy in rural communities, promote research as a tool to achieve cheaper

Period	Typology	Policy name and description
		and more efficient systems, promote international cooperation for research and technological development for renewable energies and different types of agreements, and establish collaboration networks between national and international research centers. - Market: Establish optimum conditions for productivity and competitivity of the solar energy industry, ensure compliance with environmental normativity all over the value chain of solar energy. - Finance: Establishment of optimum conditions for productivity and competitivity of the solar energy industry, bringing investments and generating formal and quality jobs. - Legitimacy: A website with all the relevant documents of this law must be developed, creation of the National System for energy information that aims to register, organize, update and disseminate information related to the sustainable use of energy, publish of a catalog with devices and equipment and information about energy consumption.
2010	Regulation	*NMX-ES-004-NORMEX-2010-Energía Solar (2nd version)* National voluntary norm that establishes how to perform the thermal evaluation for solar systems water heating processes - Market: Boost market by increasing reliability on SWH equipment - Legitimacy: Increased legitimacy by developing quality standards
2011	International Initiative	*Green mortgage – CONAVI (SISESIVE – ECOCASA)* New regulations for Green mortgage, every mortgage must include SWH. Collaboration with the GIZ. - Knowledge: Development of a tool to evaluate housing efficiency and increase knowledge of end-users about energy savings - Market: Boost market by promoting acquisition of SWH and PV's - Finance: Promote end-user financial solutions for the acquisition of PV and SWH. - Legitimacy: Develop a tool to evaluate the house efficiency and promote the acquisition of efficient equipment.
2011	Regulation	*Set of eight norms for PV systems* - Market: Boost market by increasing reliability on PV equipment - Legitimacy: Increased legitimacy by developing quality standards
2012	International initiative	*Program to Promote Photovoltaic Systems (PROSOLAR)* - Knowledge: Identification of the already existing capacity building programs and its improvement. - Market: Promotion of regulatory instruments to facilitate the transfer of electricity generated by PV plants to the CFE, promotion of development of necessary norms to ensure the quality of PV systems and of its installation, promote a certification mechanism for PV system installers, promote infrastructure for certification in Mexican laboratories and consolidate the capacities of the test laboratories. - Finance: Analysis of the activities of the private bank for financing PV systems, structure a proposal for a guaranty fund with public resources, and form a workgroup for the development of a financial mechanism. - Legitimacy: Promotion of education, awareness-raising, sensitization and information diffusion programs to transit

Period	Typology	Policy name and description
		towards a low carbon economy and adaptation to Climate change, norms will be published to establish criteria, technical specifications, and procedures to guarantee measures against climate change and pilot projects will be made to increase legitimacy
2012	Law	*The General Law of Climate Change (LCC)* - Knowledge: promote education, research, development and technology transfer for the topics related to adaptation and mitigation to climate change, fiscal incentives for research, incorporation or utilization of mechanisms, equipment, and technologies with the aim to avoid or control emissions and to research to renewable energies and low carbon technologies. - Market: Norms promotion to establish criteria, technical specifications and procedures to guarantee measures against climate change. - Finance: Creation of the fund for the energy transition and the sustainable use of energy - Legitimacy: promotion of education, awareness-raising, sensitization and information diffusion programs to transit towards a low carbon economy and adaptation to Climate change, norms publication to establish criteria, technical specifications and procedures to guarantee measures against climate change
2013	National Initiative	*National Strategy for Climate Change (ENCC)* - Knowledge: promote bilateral cooperation, experience sharing and better practices in south-south cooperation, promote research, development, and adaptation of advanced technology for renewable and clean energy generation like oceanic, solar, hydrogen, bioenergy, etc. - Market: Design economic, fiscal, financial and market instruments to incentivize mitigation and adaptation actions, strengthen the regulatory framework, institutions and the use of economic instruments to use clean energy sources, development of tax policies and economic and financial instruments with a climatic approach - Finance: Develop economic, fiscal, financial and market mechanisms in national policy to promote mitigation and adaptation actions, identify and promote the access to international finance for mitigation and adaptation actions, strengthen the regulatory framework, institutions and the use of economic instruments to harness clean energy sources and more efficient technologies. - Legitimacy: promote the appropriate and adequate information about emissions associated with production, commodities, and services available in the market, strengthening of the regulatory, institutional and economic instruments for clean energy sources and efficient technologies
2013	Initiative	*Sectorial Energy Program (PROSENER)* - Knowledge: promote the development of information and communication technologies for the diffusion of potential renewable energy zones, strengthening of the public, social and

Period	Typology	Policy name and description
		private sectors capacities for transition and energy efficiency capacities. - Market: instrument market mechanisms and regulations for clean and renewable energies supported by public and private investments. - Legitimacy: increase the available information to promote renewable energies and energy efficiency, strengthening of the regulation to meet standards for energy efficiency.
2013	Actor	*Creation of the Mexican Center for Innovation in Solar energy (CEMIE-SOL)* - Knowledge: Development and technological innovation for the solar energy sector
2014	National Initiative	*Installation Guide for SWH* - Market: provision of the minimal requirements for correct installation of SWH.
2014	National Initiative	*Strategic Program for Human Resource Building in Energy-related topics (PEFRHME)* - Knowledge: Promote the formation of specialized and high-level human capital, increase the offer of programs for the reconversion of technicians and professionals, increase offer of capacity building and certifications programs, create or consolidate capacity building centers and establish a formation and updating campaign.
2015	Law	*Energy Transition Law (LTE)* - Knowledge: Promotion of applied research and technological development, promote the development of new knowledge, materials, techniques, processes, services, and technologies, promote investment in technological development and innovation for clean energies. - Finance: Establish finance programs for solar PV micro electric grids, strengthen guarantee mechanisms for big scale renewable projects, develop financial schemes for the acquisition of renewable energy equipment, develop business models for deeper penetration of solar thermal technology, promote the development of electric-generation micro companies on a social basis in the rural and urban sector.
2015	National Initiative	*Transitions Strategy to Promote the Use of Technologies and Cleaner Technologies (ETPUTCL)* - Knowledge: promotion of formation of qualified human resources, that design, install, operate and maintain technological elements, promote research, development, demonstration of new low carbon technologies. - Market: develop finance schemes that facilitate the equipment acquisition for the use of solar energy, develop business models that facilitate the rapid penetration of the solar thermal technology. - Finance: Establish finance programs for solar micro electric grids, strengthen guarantee mechanisms for big scale renewable projects, develop business models for deeper penetration of solar thermal technology - Legitimacy: Increase the number certified solar-thermal providers
2015	International Initiative	*Solar Large-Scale Energy Program – Mexico (DKTI))*

Period	Typology	Policy name and description
		- Knowledge: Promotes research and innovation from international and national research institutes (private and public sectors), promotes technology transfer of innovating systems - Market: promotes the development of an integrated market strategy between key actors. - Finance: promotes the improvement of financial conditions for large scale solar energy applications
2017	National Initiative	*Special Program for the Energy Transition (PETE)* - Knowledge: Foster the technological and supply chain talent for renewable energies, increase the offer for the formation of professionals for clean energies, promote national and international linkages, networks and knowledge transfer to increase the national capacities in clean energies, support the research and development through the Mexican centers of research, promote linkages between academia and industry through collaboration projects. - Market: Simplify and transparentize the administrative procedures for the development of clean energies, promote the quality of information for planning and accountability, elaborate specific strategies for the development of value chains for each clean technology, promote financial schemes for the use of clean energy sources with the participation of the development and private bank. - Finance: promote the access to finance and capital by entrepreneurs, micro and medium businesses that generate energy with clean sources. - Legitimacy: promote the community participation and public consultation in the planning and development processes for clean energies