1 Introduction

Environmental concerns and sustainable development have become more prominent in international and domestic policy discussions around the world. The combination of the devastating impacts of climate change and the depletion of fossil fuels have accelerated the transition towards more efficient energy systems. Although the imperatives to mitigate the effects of global warming affect nearly all sectors from industry to transports, one of the biggest emphasis is being placed on the electricity field due to its significant contribution to worldwide greenhouse gas emissions (Solangi et al. 2011).

Electrical power is a secondary energy source traditionally generated from the conversion of primary sources of energy, such as coal, oil or natural gas. However, the past ten years have seen a global increase in the share of electricity produced by cleaner sources such as wind, solar, hydro and geothermal. While developed countries have already included these alternatives in their energy mix, a gap persists with developing countries in terms of infrastructure and technological capabilities. In many parts of the world the lack of access to reliable and affordable electricity still represents a major constraint to socio economic progress (Pfeiffer and Mulder 2013).

A country like Lebanon has been facing tough electricity problems since the end of its civil war in 1990. The Lebanese electricity sector is characterized by its huge inefficiency in supplying the country with stable and affordable electricity. The direct consequence of this energy ineffectiveness are the three to sixteen hours of daily blackouts across the country. This situation has forced Lebanese citizens to pay for expensive diesel backup generators in response to power cuts.
In this Lebanese context and with the global trend towards more environmental friendly systems, solar electricity generation has started to emerge as a potential solution to the ongoing electricity issue. Solar technologies have been able to establish a small niche market despite a hostile environment for green innovations due to the country’s political and economic instability. The market for solar electricity is growing exponentially and its products are in the process of becoming a popular alternative in the industrial and the residential sectors in order to compensate for the lack of electricity.

2. Strategic niche management

With growing concerns for climate change, environmental disorder, resource depletion and population growth, socio-technical transition studies have gained increasing attention by developing several approaches to overcome those issues through the implementation of sustainable pathways. The use of socio-technical transitions framework help explain the co-evolutionary process and interdependent dynamics that exist between technological changes and social changes related to cultural practices and politics. Thus, a sustainable transition is not only a matter of innovations and technological developments but is also a multi-actor process with a wide variety of interests and dimensions.

As part of socio-technical transition studies, strategic niche management is a framework that permits a deeper analysis of the movement taking place within a socio-technical niche. The niche can be considered as an alternative configuration to a current system or regime where new technologies and radical innovations emerge. Strategic niche management is therefore used to manage technological innovation as well as facilitate the design of policies and experiments at the niche level. In addition, it is also an analytical concept and a research model that allows a thorough exploration of the interaction between the niche and its environment.

The aim of strategic niche management is to shed light on conditions that are deemed necessary for the successful emergence of a said niche in order to overcome possible challenges and contribute to a shift in the current system. This is particularly relevant in the case of energy systems since a key concern of strategic niche management is to help enable the introduction and diffusion of new sustainable technologies such as solar power through experimentations (Caniëls and Romijn 2008).

Following the strategic niche management approach, the solar electricity niche in Lebanon is defined as a protective space with a market and a set of projects that follow specific regulations while involving a network of actors.

3. Status of solar electricity in Lebanon

Emerging solar market

The current electricity system in Lebanon with its ill-operating infrastructures that result in an increasing gap between supply and demand is an incentive for the solar electricity niche. Solar technologies offer an alternative option to meet electric energy demand in non-electrified areas as well as meeting the growing urban demand for energy. Lebanon presents an ideal situation for the use of solar technologies with the presence of abundant and evenly distributed sunlight.
as well as more than 300 sunny days a year in a moderate Mediterranean climate.

In order to generate electricity, solar photovoltaic or PV system is the most common used technology. Small PV generation systems for household lighting became available in the Lebanese marketplace in the 1990’s but were relatively unknown by the general public. Nowadays, there is an important distribution network with a variety of local suppliers who sell solar PV modules and other related by-products. Compared to the “mass market” for solar electricity solutions that exists in Europe, Lebanon is still in the preliminary phase in the development of its own solar electricity marketplace but there is a very positive dynamic underway. Since 2010 the market for solar electricity experienced strong growth rates to reach an installed capacity of 6.6 MW in 2015 (LCEC 2015). Even though it only represents 0.3% of the domestic electricity production, projections made by the LCEC indicate that this number will continue to rise in the coming years.

Solar electricity use

Given the rising electricity deficit and the importance of relying on alternative sources to reduce greenhouse gas emissions, the solar niche in Lebanon has found a small but relevant space to grow in industries, houses, commercial buildings and public institutions. In the residential sector, PV offers households the possibility for partial displacement of diesel private generators if the system is properly sized. The most common used application in that case puts together PV modules with dual mode inverters and a battery storage. This particular system allows the equipment to operate either when the grid is on in parallel mode and for several hours in autonomous mode with storage using the battery when there is no electricity. The same installation can be found in public hospitals, public schools, municipalities and community centres.

In the commercial and industrial sector, the technology used is adapted to the size of the company or industry and is based on similar solar components that can still work in combination with a diesel generator if necessary. While small scale decentralized solar electricity projects are growing, Lebanon is only just beginning the path towards more large-scale PV penetration within its electricity mix. Large open field solar power plants are being implemented across the county in order to increase the supply and diversify the sources of production (Haddad 2015).

4. Challenges

In the space of five years, the solar electricity niche has managed to stabilize and create a positive dynamic. Yet there is no major breakthrough and the transition is at a very early stage, because Lebanon is considered as a hostile environment for renewable technologies due to a number of barriers that hinder their path to wider diffusion (Harajli 2015).

4.1 The grid bottleneck

The solar electricity niche is emerging within a particular situation where the Lebanese electricity sector is managed by two main public stakeholders which are the Ministry of Energy and Water and the utility company “Electricite du Liban” (EDL). The latter has a clear monopoly over the national electricity sector as it controls 90% of the production while the rest is divided between hydroelectric power plants and distribution concessions owned by public and private corporations (Ibrahim et al. 2013). Thus, in a country that relies on centralized large-scale fossil fuel power structures for generation, distribution and end use, solar electricity represents a new technology that is not easy to integrate in the present dominating system.

From a technical standpoint, the highly inefficient and unstable grid is an important obstacle for the development of solar electricity generation in the country. The net metering issue is a good illustration of that statement. The mechanism designed to foster private investment in renewable technologies was made available in 2011 but has yet to be deployed across the county. Furthermore, the absence of 24 hour service grid power lowers significantly the efficiency of a solar system as it cannot feed-in the national network when the public utility company is absent. In addition to EDL’s lack of funding and capabilities that are necessary to upgrade and adapt the power infrastructure to any renewable technology, there is also an absence of will and skilled personnel to do so.

4.2 Economic challenges

Subsidised electricity

The introduction of a sustainable clean energy technology such as solar is not an easy task as the existing electricity system is stabilized by several rules and mechanisms. One of them is the policy of tight control over domestic energy prices mainly through the use of public subsidies. In 2009, EDL’s average total cost per kilowatt hour (kWh) amounted
to 17.14 USD cents whereas the average electricity price it was charging its consumers was 9.4 USD cents per kWh (World Bank 2009). This subsidizing regulation acts as important entry barrier to the marketplace for solar electricity application resources. From an economic point of view, low power prices are a clear form of market distortion that affect the competitiveness of renewable energy sources like PV for example. A genuine competition process without subsidies would lead to the selection of the most cost effective option. For that matter, high subsidies on electricity tend to discourage people from investing in renewable alternatives as they extend the payback period and make them less attractive in the first place.

High costs and financing

While there are some ongoing debates on whether or not solar has reached grid parity, solar products remain relatively expensive given the relative high costs of PV compared to conventional electricity (Al Attar 2015). Final prices will still differ depending on various factors including the technology, the climate, the location or the grid. Nevertheless, the cost of generating electricity from solar technologies remains too important at the moment for it to become a wide-range solution in countries like Lebanon.

The existence of power cuts that give incentives to invest in solar electricity and save on a diesel backup generator to become a semi-independent user also have their adverse effects. Interested investors have to purchase and put together a complex architecture with batteries, mounting structures, controllers and inverters in complement to the solar PV cells (Amine 2015). This constitutes a significant investment with a high upfront cost of approximately 10 000 USD in the residential sector.

The high cost of capital for solar electricity is often followed by a lack of access to financial institutions. Administrative procedures to install solar panels and receive financial support from the banking circuit follows strict rules. The process for funding is usually complex and very bureaucratic causing costly delays and long lead times.

4.3 Political and institutional challenges

Geopolitical risks

Institutions and policies play a decisive role in fostering or inhibiting the diffusion of a new technology. A socio-technical niche like solar electricity tends to assume a stable political environment. Yet, politics and the prolonged uncertainty in Lebanon are an important obstacle for the deployment of renewable energy sources in the country. For instance, wars, terrorism, and political upheavals are external developments that increase risk for new investments in solar electricity technology.

Lack of political will

A long term transition in the energy field entails a more direct involvement from policy makers in order to promote and facilitate the deployment of renewable technologies. Although the situation has slightly improved over the past few years, Lebanon still has a lot to do in terms of renewable energy commitment and supporting policies. There is a real lack of political will on the side of Lebanese decision makers in governments and in municipalities when it comes to sustainable development or environmental issues. This represents a serious challenge for the further expansion of the solar electricity niche that requires public backing. In a country that is suffering from security problems as well as political instability, the deployment of renewable technologies is not a priority on the government’s agenda.

Absence of regulatory framework

The status quo that maintains the current electricity system in Lebanon is a disadvantage for solar technologies because they require incentives and regulations. While plenty of countries are instigating new policies designed to encourage alternative energies like renewable portfolio standards (RPS) or feed-in tariffs (FIT), specific laws tailored to renewable sources in Lebanon need to be reinforced and implemented. Regulations that are supposed to facilitate the diffusion of new technologies such as solar PV are still inadequate, not adapted enough or simply not put into action.

4.4 Social challenges

Lack of awareness

The lack of awareness is a key challenge for the expansion of renewable energy sources in developing countries alongside limited financial resources. Whereas citizens in developed states are exposed to the benefits of green technologies on a daily basis, others in developing nations are still unaware of their proven value even though the situation has considerably improved over the past decade. In Lebanon, the lack of awareness among the
population generates important misunderstandings around the costs, benefits and potential of solar electricity products. The absence of clear information about the technology and its suppliers is regarded as a market failure that requires means of correction.

Social acceptance

In the electricity sector, new technologies have to be accepted by local end-users and adapted to their lifestyles. Small decentralized applications such as solar PV represent a radical change for households and for industries compared to the electricity provided by the grid and by local private diesel generators that are very well established. Solar technology is still not able to provide a turnkey solution that would cover all the load of a house considering the high levels of electricity consumption per capita in the country.

5. Actors

Strategic niche management emphasizes the importance of networks of social actors for successful niche experimenting and the development of sustainable technologies (Caniëls and Romijn 2008). Actors are the ones who help the technology progress and improve through learning and gradual experimentation in order for it to become viable within an existing system (Smith et al. 2014). In a country like Lebanon where the government and public authorities are weak institutional players, development agencies along with international donors play a prominent role in the support of the solar electricity niche.

5.1 Local development agencies

Most of the experiments in solar technology take the form of development projects led by local NGO’s, universities, semi-governmental agencies and international organizations (Perakis et al. 2012). Their activities are vital to push away some of the main challenges that the solar niche is facing in terms of awareness, visibility, distrust, technical issues, financial accessibility and political commitment.

LCEC

The Lebanese Centre for Energy Conservation (LCEC) is presently the central contact point for any energy efficiency or renewable energy project in the country. With its expertise in solar technology, its numerous studies and the basic information it provides to the general public, the semi-governmental agency is one of the main actors behind the solar niche’s recent progress in the country. LCEC also works on policy support and implementation through active lobbying as previous achievements include the implementation of the loan and financing mechanism known as National Energy Efficiency and Renewable Energy Support Action program (NEEREA), the development of the National Energy Efficiency Action Plan (NEEAP) and the drafting of the “2010 Electricity Sector Policy Paper” (see section 6.1 Policies and financing mechanism).

CEDRO

As part of the United Nations Development Program and with funding from the Spanish government, CEDRO’s first three phases focused on the installation of small scale decentralised solar systems in public facilities. Since 2014, the CEDRO project shifted its attention to the commercial and industrial sectors to work on more large-scale projects with funding from the European Union. CEDRO delivers support to factories and private companies by bidding for contractors, conducting feasibility studies, and launching the project on the ground. The project is administering several demonstration projects across the country as its main objective is to help establish the solar electricity market through facilitating work between donors and beneficiaries. In parallel, CEDRO along with DREG (Small Decentralized Renewable Energy Power Generation), another UNDP project with funding from the Global Environment Facility (GEF), focus on pre-feasibility studies and data monitoring with the aim of documenting existing solar electricity performances and carry out cost benefit analysis of solar electricity generation technologies.

5.2 International donors

International donors are important stakeholders in the promotion of renewable technologies as they take an active role in the establishment of specific and credible roadmaps while funding multiple demonstration projects on ground (Smith et al. 2014). In Lebanon, international organizations participate in the development of the solar electricity niche by coordinating with local agencies and providing necessary resources such as money, people and expertise.

The UN

The majority of international requirements and targets related to energy sustainability are set by UN international environmental conventions and protocols. For instance, it was during the Copenhagen Climate Summit in 2009 that the Lebanese
government aligned itself with the global agenda and made a pledge to produce 12% of its electricity in 2020 through the use of renewable energy sources. This political commitment then became a major part of the 2010 Electricity sector policy paper (MEW 2010). With its robust network and capacity building activities involving many local stakeholders, UNDP is a top player in solar electricity development as it manages several grants provided by foreign governments destined for the implementation of solar demonstration projects.

The EU

The European Union is currently the number one international donor in Lebanon as it executes a total budget of 2.5 USD billion of assistance in the country (EEAS, 2015). The organization is a strong advocate of solar technology in the Mediterranean area with important development projects such as the Solar Mediterranean Plan. The office of the European Commission in Beirut works in close partnership with local stakeholders like UNDP and the LCEC in order to expand the solar electricity niche through pilot projects, training and workshops while leading institutional coordination and lobbying activity to encourage Lebanese authorities to enforce legislations favouring the deployment of solar technologies.

6. Drivers

Actors play a decisive role in the support of the solar electricity niche through their activities that have materialised over the past few years with the constant growth of the solar electricity market. Whether this support takes the form of active lobbying, financial incentives, demonstration projects or awareness campaigns it remains vital in the continued emergence of the solar electricity market in the country.

6.1 Policies and financing mechanism

Public policies are important intervention tools for the protection and nurturing of a socio-technical niche (Geels 2002). An effective renewable energy policy requires a combination of measures including regulations, financial incentives and information provision. Through their dynamic mobilisation and coordinated lobbying efforts, the network of local and international stakeholders supporting the solar electricity niche in Lebanon have been able to put pressure on the government and promote several important renewable energy policies that are now institutionalised. Furthermore, incentives mechanism have been formed in partnership with the Central Bank of Lebanon (BDL) in order to boost the renewables and solar market in particular.

2010 policy paper for the electricity sector

The 2010 policy paper for the electricity sector was developed by the MEW and endorsed by the Lebanese government in 2010 as a result of its participation in the 2009 Copenhagen Climate Summit. This plan defines the country’s strategy and expectation for the electricity sector and renewable energy sources for the year 2020. In terms of regulatory measures, it recommends the development of an energy conservation law that will provide a platform of standards and rules for the use of renewable energies as well as the devise of financing schemes to encourage their diffusion (MEW 2010). Solar PV is seen as a key solution to reach the 12% renewable target for 2020.

NEEAP

The current National Energy Efficiency Action Plan (NEEAP) for the years 2016-2020 outlines a number of energy efficiency initiatives targeting the different sectors of the Lebanese economy. This plan follows up the previous NEEAP for 2010-2015 which established 14 priorities in order to reach the defined objective of the 2010 policy paper. It is a concrete illustration of the collaboration between the main stakeholders involved in the solar electricity niche since it has been developed by the LCEC with the help of the EU and the financial and administrative support of UNDP (MEW 2011). The 7th initiative dedicated to solar energy aims to start the development and promote the generation of electricity through the use of PV with a target of 200 MW in 2020. The NEEAP mentions the need for the application of financial incentives as well as the inclusion of the private sector and private investors in the process (MEW 2011).

NEEREA

The National Energy Efficiency and Renewable Energy Support Action program (NEEREA) is the first scheme in Lebanon dedicated to support the financing of renewable energy projects. The program was brought into existence in 2011 as the 11th initiative of the NEEAP and was initiated by the LCEC and UNDP, in partnership with the MEW and the BDL. The EU through the European Investment Bank (EIB) is also contributing to NEEREA by allocating specific
grants to private companies, NGO's and any private user wishing to move towards renewable energy sources. NEEREA offers interest free long term loans to eligible and feasible sustainable projects coming from individuals or private sector entities (RCREEE 2014). Such a financing scheme is an important incentive for the expansion of the solar electricity niche as it can boost the penetration rate of solar technologies and reduce their high upfront cost. In 2014, the loan ceiling reached a record 400 million USD and solar PV projects represented.

![Figure 2: Implemented projects through NEEREA by technology (RCREEE 2014)](image)

### 6.2 Demonstration projects

Experimental projects for the deployment of path breaking innovations are complementary to policy measures. The solar electricity niche benefits from the installation of solar technology in real life conditions which provides space for demonstration while allowing experts to assess the technical and economic feasibility of the system.

**Small scale projects**

CEDRO under the sponsorship of UNDP and with Spanish funding started implementing small scale solar PV projects in 2009. The targeted beneficiaries of the first three CEDRO phases were public institutions such as schools, municipalities, hospitals and community centres (Harajli 2015). The objective of these decentralized demonstration projects was to experiment solar electricity on small scale level and to acquire technological and social feedback.

**Industrial projects**

In 2014 CEDRO decided to launch its new phase in parallel of the NEEREA program and its positive impact on the commercialization of solar electricity products. The current applications of CEDRO phase IV are up-scaled and target exclusively the commercial and industrial sectors. Projects are co-financed by the private beneficiaries themselves, on top of the grant component that comes from the European Union funding to the UNDP CEDRO project. Such demonstration projects do not only increase the visibility of solar electricity but also help expand the diversity of actors involved in the solar niche network by including private stakeholders.

**Utility scale**

In 2015, the expansion of the solar electricity niche in Lebanon was illustrated by the implementation of utility scale demonstration projects. After a construction period of nine months under the supervision of the LCEC, the Beirut River Solar Snake (BRSS) was completed in April 2015 and connected to the national grid. With 3600 solar panels and a capacity of 1MW that will be added to the national grid, the BRSS is the largest solar application in Lebanon (BRSS Lebanon 2015). Located in a densely populated area of the capital, the project constitutes a landmark effort to increase private interest in solar power. Another similar 1 MW demonstration project was launched in July 2015 by the MEW and the LCEC in Zahrani.

### 6.3 Creation of a local market

In the space of 5 years, stakeholders activities combined with an efficient finance mechanism managed to trigger the solar private market...
development that is now expanding at a fast rate. The solar electricity niche has now established itself in a small market that is evolving thanks to a growing demand and a better source of supply.

International solar markets

Solar electricity generation in Lebanon follows the global positive dynamic in favour of solar products. PV applications have been growing at a very rapid pace in recent years due to technical improvements and government policies supportive of renewable energy deployment (Timilsina et al. 2012). All the incentive programs provided to solar products have facilitated the creation of important local markets in Europe which in turn have created economies of scale reducing drastically the cost of the technology. Solar technologies are becoming more competitive as their declining cost have facilitated the expansion of the solar niche in Lebanon.

Increasing demand

In 2008, solar electricity products were not affordable and were seen as a luxury product. A small PV system with storage in the residential sector used to cost approximately 28,000 USD whereas the price of the same installation is currently at 10,000 USD. Yet even if the demand is rising, solar electricity solutions are still in an early development phase when it comes to houses and apartments since the majority of Lebanese citizens can’t afford to spend this amount of money. Those who currently invest in solar technology in the residential sector are early pioneers that are not only motivated by making savings on the diesel backup generator but also have a strong environmental consciousness.

In the industrial and commercial sector, the demand has been generated because solar electricity is a cost competitive solution compared to the private generator. Narratives used to convince private companies to invest in solar are targeting financial matters such as the reduction of the electricity bill and the opportunity to become independent or semi-independent in terms of electricity generation. Private companies are more willing to invest in new solar technologies now than 4 years ago because the perceived risk of the investment has considerably gone down especially with the guarantee on their loan by the BDL.

Improved supply

The local solar market has grown exponentially as the technology has become more and more available with nearly 70 local suppliers compared to 15 in 2010 (Amine 2015). The market is currently wide open and there is serious competition among companies selling solar technology to provide the best services at the lowest price creating internal economies of scale. The lack of know-how and skilled labour that usually characterizes underdeveloped market is no longer the case as solar firms have trained engineers and experts who acquired experience by working with CEDRO or the LCEC on previous projects (Harajli 2015). This growing trend on the supply and demand side is a major element in the support of the expansion of the solar electricity niche.

7. Conclusion

The strategic niche management framework permits a better understanding of the emergence of the solar electricity niche in Lebanon. Despite a very unfriendly context for renewable energy sources illustrated by multiple challenges, solar electricity technologies were able to penetrate the local marketplace and offer potential solutions to the long lasting issues of the Lebanese electricity sector. The involvement of international donors and local development agencies is a major factor contributing to the solar niche’s current success. Those actors are behind the formulation and implementation of important national policies and financial mechanisms which accelerated the diffusion of solar electricity solutions in the country. Through the demonstration projects that were initiated on different levels, the network of stakeholders managed to push away some of the technical obstacles, raised awareness about the technology’s potential and laid the ground for the creation of a local market. The solar electricity niche is expected to continue its progression as Lebanon agreed to reduce its greenhouse gas emissions by 30% in 2030 during the last COP21 held in Paris in 2015.
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