Decentralized Renewable Energy Communities as Nodes in the Energy Transition Network: The Case of Southern Europe

Marula Tsagkari[1] & Jordi Roca Jusmet[2]

[1]*Universitat Autònoma de Barcelona, Institute for Environmental Science and Technology*
[2] *Universidad de Barcelona, School of Economics*

Abstract

Today, the hierarchically organized climate governance that dominated the era of fossil-fueled economies is being slowly replaced by a joined network of decentralized governance. This network includes various actors with different organization and visions, like municipalities, cooperatives, cities, NGOs and technical institutions. Given the growing involvement of non-state actors´ in global energy policies and the increased number of grassroots movements, this paper aims to understand the formation, design, evolution, and effectiveness of these initiatives. Decentralized energy communities are considered central nodes and potential sources of innovation in the energy transition network. The potential benefits of these communities include energy democratization, social acceptance and a change in the communities' lifestyle. However, these communities vary in their organization, function and efficiency patterns. Thus, this present paper focuses on three case studies from Southern Europe and Spain (Hierro), Portugal (Graciosa) and Greece (Tilos), where the idea of energy communities is still nascency. These communities interact between them and with various governmental and supranational actors creating a complex network. The present analysis examines the main differences in the governance and organization of these communities, the role of different actors involved, and explores the opportunities and barriers for the design of a network of decentralized energy communities.

Keywords
Local Government, Climate Change, Southern Europe, Energy, Energy Policy

1. Introduction

Climate change poses high risks in most island ecosystems in the world. The European islands are widely recognized as highly vulnerable to climate change with forecasts of severe changes in temperature and precipitation, rising sea level , aridity, severe wildfires and biodiversity loss, among others (Moreno et al., 2005; Cramer et al, 2018). With an average GDP per capita 80% lower that the EU average, the majority of the European islands are highly depended on the mainland for resources and energy. The high isolation levels increase further the dependence on imported fossil fuels, which in turn raise the cost for electricity production, and maintenance. The role of islands and island states in the transition to clean energy sources and energy security, has been recognized and was highlighted by the presidency of the Republic of Fiji in the 2017 United Nations Climate Change Conference (COP 23).

Nowadays, for most of the small islands in Europe it is not economically viable to have electricity interconnection with the mainland and thus, they depend either on local generators or they have an underwater connection with bigger neighboring islands (Kougias, 2019). A promising alternative are the small scale decentralized energy systems which take advantage of renewable energy sources locally available in remote areas in order to increase self sufficiency in the isolated communities. Nowadays, many islands worldwide have turned to these decentralized energy systems aiming to become "100% self sufficient" (Eurelectric, 2012). A decentralized energy system is based on distributed generation closer to the point of consumption. Those systems normally consist of a micro-grid system that operates independently from the main grid and provides energy produced from local sources, often renewable (wind, solar, biomass, geothermal, hydro etc) (ITRE, 2009). The systems are often complemented with energy storage solutions like batteries and hydrogen storage.

Reducing the dependency on fossil fuels has been a priority for many islands worldwide in order to overcome the environmental and economic burdens posed by the high level and to support energy security. Many of the policies focus on the use of local sources and especially on renewable resources in order to cover the local demand. Currently there is an increased need for a deeper analysis of the insular decentralized energy systems which are emerging especially regarding the use of cutting edge technologies, and the specific special legislative frameworks in which they operate.

In this context, the article analyzes the emergence and development of decentralized renewable energy systems as social niches which can push not only for a simple shift in energy generation technology, from fossil to renewable energy sources (RES), but for a social shift in the energy management and consumption system in the countries of Southern Europe. In the established regulatory and market frameworks in Greece, Spain and Portugal, various local and regional initiatives are being developed implementing new structures and challenging the old regimes. In this line, we assume that these decentralized energy initiatives (local or regional) oppose to the established regimes of electricity generation, as it is also discussed by Fuchs and Hinderer (2014). Applying the challenger actors theory by Fligstein and McAdam (2014) and the Strategic Niche Management (SNM) theory (Weber 1999; Hoogma et al., 2002), this comparative case study analysis aims to question what actors and policies are driving the transition processes and to what extent. We also discuss how some heterogeneous local projects might be contributing to niche development and a deeper change in the overall system of electricity generation.

The rest of the paper proceeds as follows. In **Section 2** we briefly analyze the theoretical context of the paper addressing the Strategic Niche Management Theory, the challenge actors theory and the role of intermediary actors. In **Section 3** we present the methodology. In **Section 4** we introduce the three cases in more detail followed by an analysis of the present policy framework regarding decentralization and system of electricity generation in the three countries. **Section 5** we apply the frameworks to analyse the three case studies and we discuss the most important findings. **Section 6** concludes.

2. Theoretical Context

2.1 Strategic Niche Management

The Strategic Niche Management (SNM) framework is an evolutionary analytical tool focused on understanding the gap between R&D and market success regarding new technologies. This phenomena is related with the “locked-in” socio- technical regimes which define the set of rules according to which, actors like firms, users and policymakers act (Caniëls & Romijn, 2008; Ruggiero et al., 2018). The established regimes are less open to the emergence of radical technologies that require a change in important system parameters. Thus, in order for a radical change to happen, innovations must come from outside the regime, and the transformations need to develop in niches. Niches are protected spaces in which experimentation can take place and new technologies can incubate and mature (e.g. Schot and Geels, 2008; Seyfand et al., 2014). In this line the SNM aims to analyze the success and failures of niche creations and to provide a tool for the management of innovations for sustainability. According to the SNM theorists the development of niches depends on three key elements: (i) expectations; (ii) social networks; and (iii) learning processes.

Concrete and well defined expectations which are shared by many actors and are successfully substantiated by the project are a crucial element of the niche formation process. Learning processes focus on generating knowledge and changing the cognitive framework in order to overcome barriers and constraints of the innovation. During this learning process the various niche actors reflect on the niche development and adapt their views and expectations. Networking refers to knowledge transfer and coordination among the actors. A variety of actors can support better the social niches and can create a deeper network.

2.2 Actors

Actors working in the project vary from policy actors to local and national governments, and private sector organizations such as energy utilities and external consultants. During the niche formation process these actors have different roles which can foster or deter the transition. For instance, certain actors (e.g. civil societies and market initiatives) can initiate the transition creating conflicts with other actors with established position and concrete interests within the regime (Stenzel and Frenzel, 2008).According to the theory of Strategic Action Fields by Fligstein and McAdam (2014) various challenger-actors can play a key role in shaping the energy transition. These actors interact in a broader economic, social and political field creating what is called a strategic action field. The action fields are "the fundamental units of collective action in society" in which all the collective actors (for example, firms, social movements, and governmental systems) interact in a larger political, social, or economic field. In this strategic field some actors posses more or less power and accordingly they make moves and adjustments given their position and the role of the other actors. The actors that defend the established regime are called incumbents while the challengers are the ones who push for systemic changes and thus they often enter in conflict with the incumbents.

Other important actors are the intermediary actors which facilitate the learning and the exchange of knowledge among projects (Geels and Deuten, 2006; Kivimaa, 2014). They can be actors or institutions charged with the role to create networks and to enable relationships and learning between similar niches. Their role in energy transitions and more concretely in the niche empowering processes has been examined in the research of Hodson and Marvin (2010), Hodson et al. (2013) and recently by Bush et al. (2017).

3 Methodology

Three case studies were selected for analysis and comparison characterized by various forms of community, corporate and governmental involvement in the project development and ownership. All three cases are considered pioneers in their respective countries and aim to become self sufficient depended only on local renewable energy for electricity generation. Additionally, they can be considered examples of a socio-technical niche emergence with new social institutions, values and aims that do not form part of the mainstream regime. The three cases are located in Southern Europe, in Spain, Portugal and Greece.

A comparative case study approach was chosen to bring into view the differences and similarities between these initiatives, and to illustrate their heterogeneity with regard to their locations, size, technologies, organization and motivations. The analysis is based on key concepts of the SNM framework (presented in Section 2) with a special focus on the role of various actors in the niche formation process. The analysis was based on qualitative data obtained through document analysis (energy statistics, public reports, policy papers at nation-level and state-level, review of the available scholarly literature and internet sources). In total 209 related documents were analyzed. Of those, 120 are reports, while 12 are academic journals and 77 from other internet sources.

From the energy plans reviewed, the findings are divided into three lines of discussion: the role of actors in the niche formation process, the main motivation and goals of the project and the role of policies in the emergence of the distributed energy projects.

By analyzing the aforementioned indicators we aim to examine how the decentralized energy projects in isolated islands emerged and to what extent they might be contributing to niche development. The present research focuses on the heterogeneity of the actors and the design, assuming that a combination of specific structural and organizational forms and adequate policies can help new projects and can contribute to a change in the overall system of electricity generation in isolated islands.

4. Presentation of the cases studies

The three case studies chosen are the island of Hierro (Spain), Tilos (Greece) and Graciosa (Portugal). The main characteristics of the decentralized renewable energy projects are presented in Table 1 and analyzed in the following section

	Project	**Percentage of renewables**	**Coordination**	**Budget**
EL Hierro	5 aerogenerators Enercon E-70 (1,5MW) , upper reservoir (380,000 m³), lowe reservoir (150.000m³), pumping plant (6MW)	42.2% (until 1Q 2018)	Gorona del Viento El Hierro S.A, Endesa (25%), Canary Islands Government (7%), the Cabildo of El Hierro (68%)	64,7 million
Tilos	NaNiCl2 batteries (2MWh), a 800 kW wind turbine, 592 PV panels of a total capacity 160 kW, distributed heat storage, smart meters and DSM and three weather stations.	70%	Eunice, WWF Hellas, HEDNO,Technical UNIWA (Former TEIP), Municipality	15 million
Graciosa	solar park (1 MW), 4.5MW of wind energy, 3.2MWh of lithium battery energy storage and some thermal generation using diesel for backup.	65%	Recharge A/S (50,1%), Electricidade dos Açores (EDA)	26 million

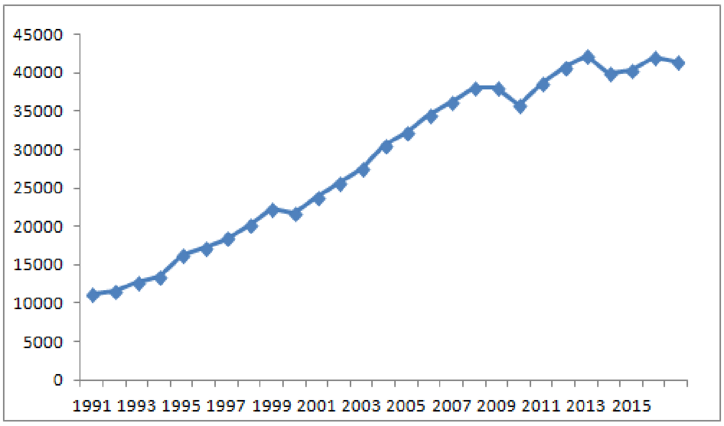
4.1 El Hierro

The island of “El Hierro” is located in the Atlantic Ocean and is the smaller and southern of the Canary Islands. The island has a total population of 10.162 people living in the three municipalities: Valverde, La Frontera and El Pinar.

Prior to the implementation of a renewable energy system, the island was depended on nine diesel units located in the Llanos Blancos power station that produced 13.36 MW/year in order to cover the increased local energy demand (**Graph 1**). This system, due to the high levels of isolation was one of the most expensive among the Canary Islands and also highly polluting (Instituto Canario de Estadística, 2019).

In 1997, the Council of the island adopted the "El Hierro Sustainability Plan", aiming to make the island the first island completely powered by renewable energy sources, and at the same time to improve the quality of life of local people and to preserve the the cultural and natural heritage. In 2014 the hydroplant (total power 11.3 MW) started its operation. The Hydro-wind project combines a wind farm and with a pumped-storage hydroelectric power station. The project consists of an upper deposit (La Caldera) with a maximum capacity of 380,000 m³ and a lower deposit of a maximum capacity of 150,000 m³. The wind farm consists of 5 aerogenerators (Enercon E-70) each with 2.3 MW of power (total 11.5 MW). The pumping plant has two 1500 kW pump sets and six 500 kW pump sets with a total power of 6 MW. During the windy days the energy excess is used to store water from the lower deposit in the upper deposit. This water is stored and can be used in days with no wind to switch on the turbines and to generating electricity in order to cover the electricity demand (Iglesias and Carballo 2011; Frydrychowicz-Jastrzębska 2018).The ambitious project aims to avoid an annual consumption of 6000 tonnes of diesel per year which is equivalent to 40000 barrels of imported oil (Godina et al., 2015).

The project is managed by the company "Gorona del Viento El Hierro S.A", funded by Endesa (25%), Canary Islands Government (7%) and the Cabildo of El Hierro (68%) (Endesa, 2019).

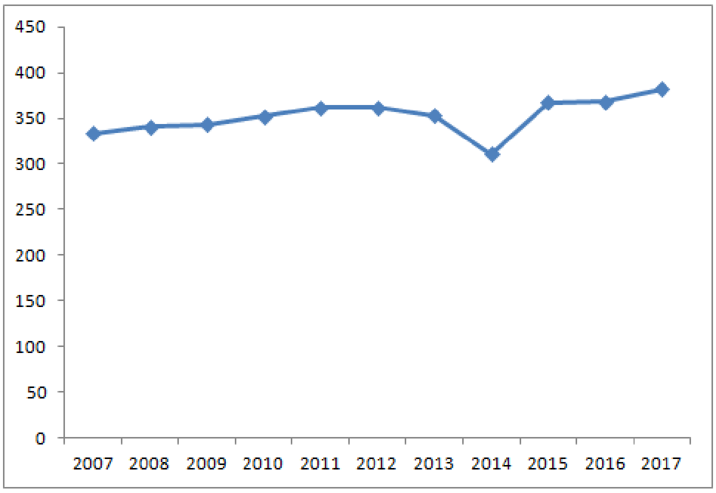


[Graph 1]. Total Energy consumption in Hierro island in MWh (1991-2017)

4.2 Tilos

The island of Tilos is located in South-East Aegean sea, has a total area of 61.49 km² and a population of 780 people. The island belongs to the Greek Islands of "Barren Line, meaning that it has limited connection with the mainland. Until now, the increased electricity demand on the island (**Graph 2**) was covered by the oil station of the nearby island of Kos. However, the connection was rather unstable with many regular and long term blackouts. In order to deal with this issue, in 2015 the local government decided the development and operation of an innovative renewable energy project. The system is a hybrid photovoltaic/wind/storage energy system that consists of NaNiCl2 batteries with a capacity of 2 MWh, a 800 kW wind turbine, 592 PV panels of a total capacity 160 kW, distributed heat storage that controls the domestic electrical water heaters and smart meters and DSM that monitor and regulate the residential and community energy loads and three weather stations (Duchaud et al., 2019).

The Tilos project is a multinational European demonstration and research project engaging 13 participating (4 industrial partners, 7 academic and research partners, 2 distribution system operators and 1 non-governmental organization) from 7 European states (Germany, Greece, United Kingdom, Sweden, Italy, Spain and France). The group EUNICE is the owner and operator of the project. (TilosHorizon, 2019).



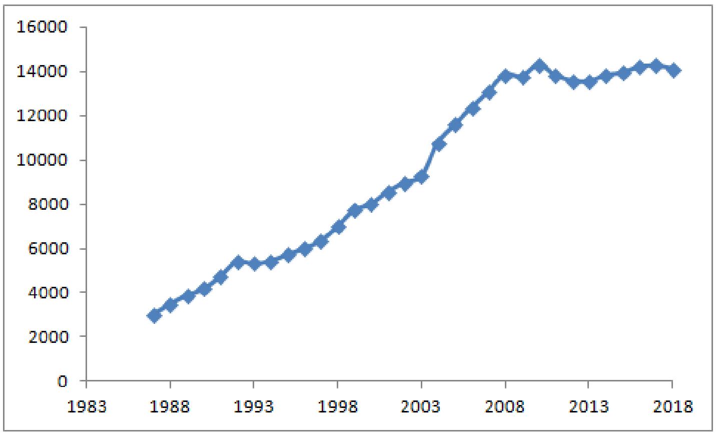
[Graph 2] Energy consumption on the autonomous system Kos-Kalymnos-Leipsoi-Leros-Tilos in MWh (2007-2018)

4.3 Graciosa

The island of Graciosa is located in the north part of the central group of Azores and has a total population of 4,777 people and an area of 60.65 km². Due to the rough topography of the seafloor an underwater connection with a submarine cable is not possible and thus, the islands are isolated from the mainland and from each other. Before the installation of renewable energy in Graciosa, the total demand of 14 GWh annually (**Graph 3**), was covered by six diesel generators (4,610 kW). With the new system, that consists of a 4,5MW wind park, a 1MW PV system and a battery-based energy storage management system (BESS) with a capacity of 3.2MWh, 65% of the local demand can be covered from renewable energy (EDA, 2017; Stenzel et al., 2017)

The project is 50,1% owned by the Danish company Recharge (Recharge is owned by Howard Scott & Partners Ltd) which is the main investor with EUR-24-million . The rest 4,5 million euros came from community funds. The developer and controler is the german company Younicos and the battery is provided by the company Leclanché . The next years, the savings from the lower use of imported diesel will be shared between the investors and the Portuguese end consumers under the Power Purchase Agreement (PPA) with local utility EDA.

The only available research regarding the project is a comprehensive Life Cycle Analysis by Stenzel et al. (2017) who concluded that the new hybrid system will reduce the environmental impacts by 43% while in the new system 60% of the impacts is due to the use of the old diesel system and only 6% due to the battery energy storage system.



[**Graph 3**] Total energy consumption in MWh (1985-2018)

5. Energy Demand and Regulatory Frameworks for isolated energy systems

5.1 Spain

The previous years Spain has been a leader in the renewable energy The RES support scheme in Spain has been based on feed-in tariffs (FITs) and feed-in premiums (FIPs) since 1998, with some rather minor reforms happening in 2004 and 2007. The FITs provide total payments per kWh of electricity of renewable origin and has been one of the most widely used systems and an effective policy to promote renewable energy in Europe. Under the FiP system, a payment per kWh on top of the electricity wholesale-market price is awarded. The combination of the feed-in tariff (FIT) and feed-in premium (FIP) schemes made Spain attractive to investors until 2010, due to high levels of stability guaranteed (Ragwitz et al., 2012).

However, the FIT tariff system led to a bubble in the investment process that together with the over compensation for nuclear and hydropower generators created, a deficit in the electricity sector of over 40 billion euros in the period 2000-2014 (European Commission, 2012). Thus, the previous FIT-FIP system was replaced with a remuneration system according to which the remuneration is calculated based on some variables like the type of the plant, the location, the remuneration for the initial investment of the plant, the remuneration of the operation, the useful regulatory life, the number of minimum and maximum generation full-load hours, the functioning threshold, the annual lower and upper limits of the market price and the average annual market price (Artigues et al., 2016). These parameters will be revised every 6 years. In January 2016, the Spanish Electricity sector launched the model of auctions for large scale projects in order to reduce the gap between the selling price and the generation cost. The private PPAs (power purchase agreements) last 20 years for wind and solar and 25 years for biomass.

The Insular and Extra-peninsular Electricity Systems in Spain include: Ceuta y Melilla, the Balearic Islands Mallorca–Menorca (Mallorca is interconnected to the mainland by cable) and Ibiza–Formentera; and the Canary Islands: Tenerife, Gran Canaria, El Hierro, La Palma, La Gomera, Lanzarote, and Fuerteventura (the latter two are interconnected). These systems due to the high levels of isolation that lead to higher investment and operating costs fall under a distinct regulation. The Law 54/1997 introduced a system of unified prices in the whole Spanish territory aiming to reduce differences in the prices between the islands and the mainland that can lead to discrimination (Uche-Soria & Rodríguez-Monroy 2018). The energy policy of the Canary islands highlights the importance of the promotion of RES aiming to increase energy independence and to minimize the costs and the emissions.

5.2 Greece

In Greece, the FIT scheme that was in place with small alterations since 1994, was replaced in with a FIP scheme that added a premium to price received by renewable generators in the wholesale electricity market in 2016. The FIP is calculated monthly as the difference between the reference price and the reference market prices. The FIP contracts of renewable energy projects participate in the wholesale electricity market. Small scale (<3 MW wind, <500 kW other RES) and demonstration projects are still subject of the FIT system. . Projects on islands continue to have access to a FIT-based scheme (through PPA) as long as these islands are either not interconnected with the mainland of Greece or do not have a fully operational daily electricity market.

The Greek electricity network can be divided into the national power grid found in the mainland and a number of smaller local grids on the islands. According to the Greek Regulatory Authority of Energy (RAE) the islands which are not powered by the mainland power grid, termed as the Non-Interconnected Islands (NIIs) of Greece, have an electricity market which consists of thirty-two autonomous systems of which, 19 are small stations (up to 10kw), 11 are medium size stations (10-100Kw) and 2 big systems can be found in Crete and Rhodes (more than 100kw). The autonomous electric system of these islands is powered mostly by electricity generated by local thermal power stations which use crude oil, heavy oil (mazut) and light oil (diesel), and in some cases by RES.

The Greek islands host 15 % of the Greek population and are responsible for 14 % of the total national annual electricity consumption (HEDNO, 2018). The operating and environmental costs of these stations burden the whole country as everybody pays higher prices through a unified system. According to the data published from RAE (2014), the total cost is more than 800 m€/ year. In this context, Greece has acknowledged that islands are a key element for the energy transition and the national economic growth (Giorgos Patoulis and Nicole Katsioulis, 2016). For this reason the 10-year Development Plan of Greece include special sections dealing with the problems on island. Among others, the proposed solutions by the Ministry of Environment Energy & Climate Change (2010) is the interconnection of the islands and when this is not feasible due to financial and technical restrictions, the development of self-sufficient renewable energy systems should be considered.

The Non-Interconnected Islands Code is the main piece of legislation according to which all the energy producers on the NII have to sign an agreement with HEDNO. they are being compensated monthly for the energy they produce and sell to HEDNO and charged for any extra energy the consume.

5.3 Portugal

The FIT scheme in Portugal was launched in 1998 and lasted until 2012, with various modifications like differentiations per technology, change in the guarantee period and in the value of the tariff (Proença and Aubyn, 2013). In 2013, the FIT program gradually faced out and was replaced by a public tender regime in which sellers compete against each other for the largest discount on reference tariffs. On the contrary with Spain, Portugal did not apply retroactive cuts of the feed in tariffs but chose to keep the tariffs applicable to projects in operation, thus transmitting to the market the necessary confidence signal and ensuring the flow of investment. Up to date, there is not a direct support mechanism, or fiscal benefits for RES in place. Very recently, in January 2019 it was announced that Portugal, following the Spanish example will hold two auctions for solar projects

The autonomous power systems in Portugal include Madeira and the Azores islands. The islands of Azores located in mid-Atlantic, have limited probabilities of interconnection due to the distance from the mainland. However, due to the favorable weather conditions it has been estimated that the island have the potential to meet the local demand. Indeed the islands of Azores have been studied extensively the past years (e.g. Rodriguez et al., 2017; Ioakimidis and Genikomsakis, 2018) and have a long history of renewable energy and especially geothermal energy. Currently, there are three geothermal plants, one in Pico Alto in Terceira island and one in Pico Vermelho, in Sao Miguel island. It has been estimated that these plants will represent one fourth of all electricity generated on the Azores.

Portugal, on the contrary with Greece and Spain, did not have a unified price system for its territory in order to cover the increased prices of fuel on islands. This changed in 2003, with the introduction of the Decreto-Lei nº 182/95, that acknowledged the need to subsidize the increased price of electricity production on islands

6. Results & Discussion

6.1 Articulation of visions and expectations

The main collective drivers and goals for each project was extracted from the official documents reviewed, and are presented in **Table 2**. All three cases had very clear visions and well-defined goals and objectives which were well substantiated by the projects. Common drivers and motivations include self sufficiency, reduced energy cost, increased grid stability and reduction of CO2 emissions.

The importance of self sufficiency for isolated communities which depend on local diesel generators or fossil fuel imports is being highlighted in various studies like for example in the work of Denis and Parker (2009) in Canada and of Boon and Dieperink (2014) in the Netherlands. In a broader context, the ability to be independent of energy providers and to achieve energy autarky has been acknowledged as an important motivational factor (Deuschle et al. 2016; Ecker at el.,2017; McKenna 2018) for energy transition. Research has indicated that psychological factors like self-determination (Deci and Ryan, 1985, 2000) and the sense of control also play an important role. The emphasis given by the tree case studies in self sufficiency provides further evidence for the importance of autarky and how it can influence the development of decentralized energy supply systems.

The environmental benefits where clearly mentioned in all three cases and were measured in CO2 emissions reduction. Despite the emphasis on climate change mitigation there was not any mention on other environmental effects like water use, land use and biodiversity. The side environmental benefits were not addressed in any of the cases.

The economic motive is another important driver. Funding from local budget or from external corporations increases the pressure for economic viability. Overall, profit orientation is a main motive both for the communities and the corporations that deal with the energy supply. In the case of Tilos, the community is considering the idea to export excess of energy to the island of Kos in order to increase the profits, while in el Hierro the community is already experiencing economic benefits from selling the energy to EDA. On Graciosa, the electricity generated is also sold by Graciolica to the local utility however in this case there is no direct economic benefit for the local society.

Despite the extensive focus on the direct economic benefits due to the reduction in the cost of energy in any of the cases there was a specific mention on the indirect economic benefits, like job creation. Tourism, as a sector that can be beneficiated, was explicitly mentioned only in the cases of Tilos and Hierro. The interconnection by local renewable energy sources and sustainable tourism has been highlighted in various studies (Michalena, 2008). According to Frantál and Urbankova (2014), energy tourism is a form of industrial tourism that develops around visits on retired and operating energy sites. This new form of tourism seems to be a motivating factor for the islands studied however we did not come across any specific planning regarding energy tourism.

[Table 2]. The main priorities of the decentralized renewable energy projects examined (authors own elaboration extracted from the official project documents)

PRIORITIES/MOTIVATION	Hierro	Tilos	Graciosa
Maximizations of RES penetration	X	X	X
Grid stability	X	X	
Tourism		X	
Indirect Economic benefits	X	X	
Reduced energy cost	X	X	X
Reduced CO2 emissions	X	X	X
Self sufficiency	X	X	X

6.2 Knowledge, actors and niche development

In the present section we examine the role of various actors in the niche formation processes as these were described in Section 2. The comparative results are presented in **Table 3**

6.2.1 Initiating

When it comes to energy transitions, communities are often mobilized by endogenous actors like the local governments in the cases of el Hierro and Tilos. In both cases "green mayors" were the pushing actors that envisioned and initiated the projects. On the contrary, in the case of Graciosa an exogenous actor (Younicos), played the role of the driving force. In all three cases the initial face of the project included incentives from exogenous organizations. The incentives were typically in the form of loans or grants in order to support the preparation and implementation of the project. Additionally, external organizations did also the initial data analysis in order to evaluate the current energy consumption and forecast the future demands. However, although the incentives came from national or international entities, the response to the opportunity to establish plans in two out of the three cases was taken up at the local level by mostly by local organizations and by the local government. These results highlight the importance of exogenous organization as providers of the funding source and the technical capacity. The initiative of the local community and the local authorities is supported by those external organizations that have a catalytic role in helping the community overcome the initial budget and knowledge limitations. Thus, cooperation among the various endogenous and exogenous actors is important at this stage.

6.2.3 Managing

Moving from the envision of the project into management,the three projects can be divided according to their central institutions and their guiding principles into community oriented, state oriented and market oriented (Streek & Schmitter 1985; Oteman, Wiering & Helderman 2014). Based on that, the most community oriented project is el Hierro where the municipality holds the majority of the shares and has the leading role in the management. Tilos is more state oriented, while Graciosa is a market oriented system. This can be related with the various political systems in the three countries. While in Spain the governmental system is more decentralized and the autonomous communities have more financial means and independence for policy design, the greek system is highly centralized.

A successful management of the project includes not only management of the supply and demand in balance. Although the management of the supply is clearly defined in the projects, the demand side was approached through different strategies and mostly through implementation of Demand Side Management (DSM) and storage systems. In the case of Tilos, for the demand side management the responsible organization is an external international organization Eurosol. Two out of the three case studies, Tilos and Hierro, used initiatives that try to promote behavioral changes like energy savings in houses and business.

6.2.4 Learning and networking

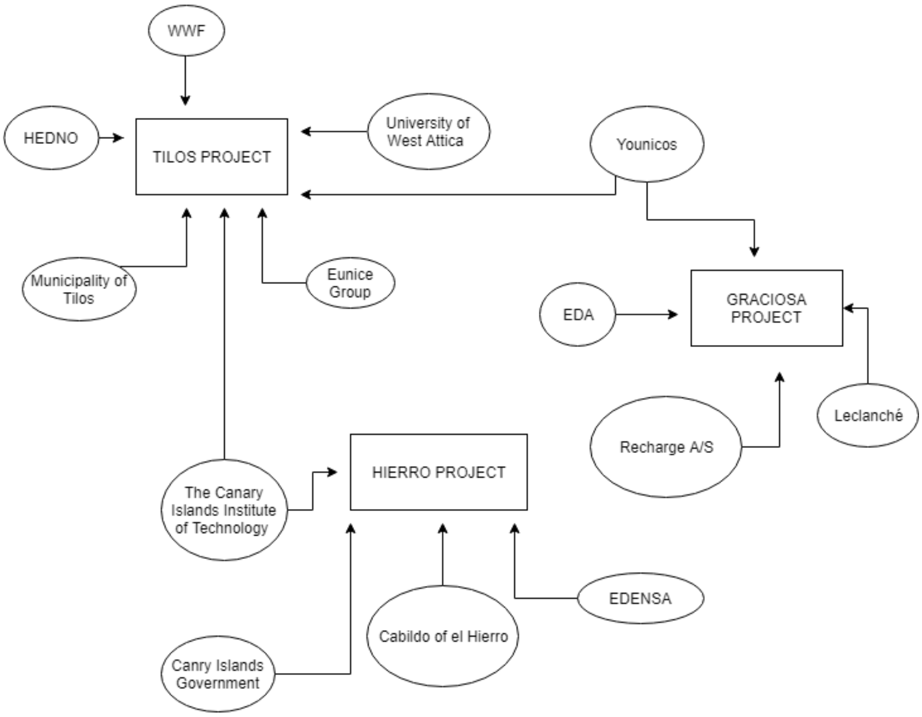
Intermediate actors, like NGOs and Universities often provide the technological knowledge and are responsible to network and share experiences. Intermediaries can also design channels and events that can bring together initiatives from local, regional and national levels. Growing niches depend on the expansion of these networks and network building activities of the participating actors.

Although learning and networking are important elements in the three cases there are some significant differences. In the case of Tilos the role of educating the public and reducing conflicts was carried by the NGO Greenpeace. The University of West Attica (former Piraeus University of Applied Science) was responsible for sharing the learning with other energy intermediaries, for the networking as well as for the project coordination. Similarly in the case of el Hierro the knowledge aggregation was also carried out by the Technological Institute of Canarias. Interestingly, in the case of Graciosa an external corporation, Tractebel was the project manager and but with not a clearly defined role of networking and learning. Despite the differences our results indicate a common learning mechanism through intermediary organizations. Additionally, the role of Universities as intermediaries, was strong in two out of the three cases examined. The importance of Universities in promoting social innovation niches, highlighted also in previous research (Benneworth and Cunha, 2015; McKelvey and Zaring, 2017; Calvo et al., 2018) is strengthened further by our observations.

The local energy providers are also key actors that serve various interests, have a balancing role and work closely with other main actors like municipalities (e.g. el Hierro, Tilos) and international corporations (e.g. Graciosa). In all three cases the projects signed contracts for selling energy to the energy providers. In this context the energy providers participate actively in the management of the demand and supply.

It is important to highlight that there is an established network among the three case studies in order to exchange knowledge and expertise. The company Younicos that financed the project in Graciosa is a consortium member in the Tilos project. Similarly the technological Institute of the Canary Islands participates in both the Hierro and Tilos project. Those are the weak ties of the network that create what Geels and Deuten (2006) call an inter-local phase in the niche scale up process. In this phase as it is depicted in **Graph 1** the shared visions and the local knowledge is been fed forward in order to form a networking among similar niches through some intermediary actors.

[**Graph 1**]. Network of the main actors participating in the niche formation process in the three case studies



Funding

When it comes to resources, these seem to come from all the levels of government (local, regional, national and European) and vary from grant funding to price support schemes. Overall external funding it is a crucial factor for the vitality of the project especially during the initial stages. Similar with what was observed in the study of van der Waal et al. (2018) the funding worked as an "interssesment device" to further boost the cooperation among the various partners and to strengthen the ties among the participating actors.

Policy

As highlighted by Toke et al. (2008), the role of national policy is an important factor when it comes to the implementation and success of local projects. Across the three countries there are noticeable differences in the dominant policy discourse as we discussed in Section 5. Greece provides stronger incentives with a FIT mechanism still in place for the non-interconnected islands while in Portugal the support scheme is less elaborate and consistent. Spain is in a transition period with a mechanism of support that is case-based.

In the case of Greece there was not a specific regime considering the hybrid renewable energy plants on islands not connected to the mainland electricity system. The Tilos project pushed for national legislation synchronized with the local needs and a new policy regime adopted in 2016, based on tenders for other similar future projects. It seemed that all three initiatives paved the way for legislation that spurs the local projects of renewable energy in the isolated islands. Currently one can observe many similar initiatives in the three countries like on the island of Ikaria and Ai-Sartis in Greece, Menorca in Spain and Madeira in Portugal. This is an indication that the decentralized renewable energy projects are scaling up from being isolated niches into a trans-local network with high potential to change the local regime.

Incumbent actors

In all three cases, the electricity distribution is a monopoly that has been well established the past years. In all the cases however, the energy providers participated in the local initiative. The low levels of resistance can be explained due to the fact that the energy providers through contracts buy the renewable energy produced and thus are not being excluded from the new regime. Our results are in line with the findings of (Hekkert and Negro, 2009) who pointed out that the increased competition increases pressure to invest and thus often the incumbent actors get involved in new technologies. This is often through collaboration in order to limit the risks and costs (Fontes et al., 2013) as is also seen in our cases. These "cooperation strategies" are often mutually favorable for the challengers and the incumbents (Rothaermel, 2001)

Additionally, the energy providers are in a position of power as in all of the case examined the local communities do not aim to disconnect completely from the grid. On the contrary, they need to have a energy backup in order to deal with the problem of intermittency of the renewable energy sources and the lack of affordable energy storage technologies. This makes the distribution operators crucial actors in the process.

[Table 3] The main actors participating in the stages of the niche formation process

	Initiating			Learning			Networking			Suppoting			Funding			Managing		
	Hierro	Tilos	Graciosa	Hierro	Tilos	Graciosa	Hierro	Tilos	Graciosa	Hierro	Tilos	Graciosa	Hierro	Tilos	Graciosa	Hierro	Tilos	Graciosa
Actor										X	X	X			X	X	X	
Municipality	X	X		X	X	X												
State													X	X			X	
University				X	X													
National corporations													X		X	X	X	
International corporations			X						X									X
Distribution operators																X	X	X
European Union							X	X						X				
Non governmental organizations					X													

6. Conclusions

In this paper we used the Strategic Niche Management (SNM) theory and examined the role of various actors in order to analyze three decentralized renewable energy projects on isolated islands. The projects demonstrated high levels of heterogeneity but all had some common denominators including clear motives, strong intermediary actors and support from the local energy providers and the community. Additionally, the results indicate that three key factors from the SNM theory (building networks, managing motivations and facilitation of learning) as well as the participation of concrete actors in these processes, are of great importance for all three cases.

Our paper started with the assumption that the decentralized renewable energy initiatives studied, are pioneers in the efforts to change the electricity supply system in their respective countries. Indeed, we conclude that the case studies can be considered important niches for innovation that have created a new policy and structural regime, enforced new institutions and designed new ambitions.

Decentralization is not only an important innovation for energy production but also a new form of energy management often dominated by different actors than the established electricity system. In this line, a heterogeneous group of actors that are less visible in the established regime play an important role in the various niche nursing stages, like mayors, universities and NGOs. On the contrary, incumbent actors can hold new roles in the new decentralized management (e.g. the energy providers) and cooperate with the new actors. This can be beneficial for the incumbent and reduces the lines of conflict among challengers and incumbents.

Given the diversity of actors involved, strategies developed, and organizational forms established, we can talk about an heterogeneous emergent field that is not yet stabilized but with some common characteristics. Nonetheless considering the heterogeneity among the cases, although we chose representative cases we cannot claim generalisability. Building on the present analysis it would be appropriate to collect qualitative data and to further discuss other similar initiatives which are currently on the initial stages.

Insofar, it is also very difficult to say which of the analyzed cases will survive, to what extent they will achieve their aims and the influence they will have on the overall energy transition nationally and globally. Various challenges will have to be overcome as the projects move from the trans-local to the global phase but there are indications that this transition is already happening in the countries of Southern Europe. The aforementioned initiatives offer a promising alternative to the established regime and with the required attention and support can have the potential to contribute to a shift on the energy generation field.

References

References

Boon, F., & Dieperink, C. (2014). Local civil society based renewable energy organisations in the Netherlands: Exploring the factors that stimulate their emergence and development. *Energy Policy*, *69*, 297-307. doi:10.1016/j.enpol.2014.01.046

Bush, R., Bale, C., Powell, M., Gouldson, A., Taylor, P., & Gale, W. (2017). The role of intermediaries in low carbon transitions – Empowering innovations to unlock district heating in the UK. *Journal of Cleaner Production*, *148*, 137-147. doi:10.1016/j.jclepro.2017.01.129

Caniëls, M., & Romijn, H. (2008). Strategic niche management: towards a policy tool for sustainable development. *Technology Analysis & Strategic Management*, *20*(2), 245-266. doi:10.1080/09537320701711264

Cramer, W., Guiot, J., Fader, M., Garrabou, J., Gattuso, J., & Iglesias, A. et al. (2018). Climate change and interconnected risks to sustainable development in the Mediterranean. Nature Climate Change, 8(11), 972-980. doi:10.1038/s41558-018-0299-2

Deci, E., & Ryan, R. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum.

Deci, E., & Ryan, R. (2000). The "What" and "Why" of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychological Inquiry*, *11*(4), 227-268. doi:10.1207/s15327965pli1104_01

Deutschle, J., Hauser, W., Sonnberger, M., Tomaschek, J., Brodecki, L., & Fahl, U. (2015). Energie-Autarkie und Energie-Autonomie in Theorie und Praxis. *Zeitschrift für Energiewirtschaft*, *39*(3), 151-162. doi:10.1007/s12398-015-0160-5

Duchaud, J., Notton, G., Fouilloy, A., & Voyant, C. (2019). Wind, solar and battery micro-grid optimal sizing in Tilos Island. *Energy Procedia*, *159*, 22-27. doi:10.1016/j.egypro.2018.12.012

Ecker, F., Hahnel, U., & Spada, H. (2017). Promoting Decentralized Sustainable Energy Systems in Different Supply Scenarios: The Role of Autarky Aspiration. *Frontiers in Energy Research*, *5*. doi:10.3389/fenrg.2017.00014

Endesa (2019) El Hierro renewable, an example of sustainability - *Endesa.com*. Retrieved 2 April 2019, from https://www.endesa.com/en/projects/a201611-el-hierro-renewable-sustainability.html

Eurelectric. (2012). EU islands: Towards a sustainable energy future. Www3.eurelectric.org. Retrieved 2 April 2019, from https://www3.eurelectric.org/media/38999/eu_islands_-_towards_a_sustainable_energy_future_-_eurelectric_report_final-2012-190-0001-01-e.pdf

Fligstein, N., & McAdam, D. (2014). The Field of Theory. *Contemporary Sociology: A Journal of Reviews*, *43*(3), 315-318. doi:10.1177/0094306114531283a

Fontes, M., Sousa, C., & Pimenta, S. (2013). Entry strategies in the face of incumbents dominant position: the case of advanced renewable energy technologies. In ICEE Conference. Retrieved from https://repositorio.iscteiul.pt/bitstream/10071/5901/1/Fontes%20Sousa%20Pimenta%20-%20ICEE%202013.pdf

Frantál, B., & Urbánková, R. (2014). Energy tourism: An emerging field of study. *Current Issues in Tourism*, *20*(13), 1395-1412. doi:10.1080/13683500.2014.987734

Frydrychowicz-Jastrzębska, G. (2018). El Hierro Renewable Energy Hybrid System: A Tough Compromise. *Energies*, *11*(10), 2812. doi:10.3390/en11102812

Fuchs, G., & Hinderer, N. (2014). Situative governance and energy transitions in a spatial context: case studies from Germany. *Energy, Sustainability and Society*, *4*(1). doi:10.1186/s13705-014-0016-6

Geels, F., & Deuten, J. (2006). Local and global dynamics in technological development: a socio-cognitive perspective on knowledge flows and lessons from reinforced concrete. *Science and Public Policy*, *33*(4), 265-275. doi:10.3152/147154306781778984

Godina, R., Rodrigues, E., Matias, J., & Catalão, J. (2015). Sustainable Energy System of El Hierro Island. *Renewable Energy and Power Quality Journal*, 46-50. doi:10.24084/repqj13.232

Hekkert, M., & Negro, S. (2009). Functions of innovation systems as a framework to understand sustainable technological change: Empirical evidence for earlier claims. *Technological Forecasting and Social Change,* 76(4), 584-594. doi:10.1016/j.techfore.2008.04.013

Hodson, M., & Marvin, S. (2010). Can cities shape socio-technical transitions and how would we know if they were?. *Research Policy*, *39*(4), 477-485. doi:10.1016/j.respol.2010.01.020

Hodson, M., Marvin, S., & Bulkeley, H. (2013). The Intermediary Organisation of Low Carbon Cities: A Comparative Analysis of Transitions in Greater London and Greater Manchester. *Urban Studies*, *50*(7), 1403-1422. doi:10.1177/0042098013480967

Hoogma, R., Kemp, R., Schot, J., & Truffer, B. (2002) Experimenting for Sustainable Transport: the Approach of Strategic Niche Management. *Spon Press*, London

Iglesias, G., & Carballo, R. (2011). Wave resource in El Hierro—an island towards energy self-sufficiency. *Renewable Energy*, *36*(2), 689-698. doi:10.1016/j.renene.2010.08.021

Ioakimidis, C., & Genikomsakis, K. (2018). Integration of Seawater Pumped-Storage in the Energy System of the Island of São Miguel (Azores). *Sustainability*, *10*(10), 3438. doi:10.3390/su10103438

ITRE -European Parliament's Committee on Industry, Research and Energy (. (2012). European Renewable Energy Network. Retrieved from http://www.europarl.europa.eu/meetdocs/2009_2014/documents/itre/dv/renewable_energy_network_/renewable_energy_network_en.pdf

Kivimaa, P. (2014). Government-affiliated intermediary organisations as actors in system-level transitions. *Research Policy*, *43*(8), 1370-1380. doi:10.1016/j.respol.2014.02.007

Kougias, I., Szabó, S., Nikitas, A., & Theodossiou, N. (2019). Sustainable energy modelling of non-interconnected Mediterranean islands. Renewable Energy, 133, 930-940. doi:10.1016/j.renene.2018.10.090

McKenna, R. (2018). The double-edged sword of decentralized energy autonomy. *Energy Policy*, *113*, 747-750. doi:10.1016/j.enpol.2017.11.033

Michalena, E. (2008). Using Renewable Energy as a Tool to Achieve Tourism Sustainability in Mediterranean Islands. *Études caribéennes*, (11). doi:10.4000/etudescaribeennes.3487

Mir-Artigues, P., Cerdá, E., & del Río, P. (2018). Analysing the economic impact of the new renewable electricity support scheme on solar PV plants in Spain. *Energy Policy*, *114*, 323-331. doi:10.1016/j.enpol.2017.11.048

Moreno, J.M. (2005), Evaluación Preliminar de los Impactos en España por Efecto del Cambio Climático. Proyecto ECCE – Informe Final, MMA and UCLM,

Oteman, M., Wiering, M., & Helderman, J. (2014). The institutional space of community initiatives for renewable energy: a comparative case study of the Netherlands, Germany and Denmark. *Energy, Sustainability and Society*, *4*(1), 11. doi:10.1186/2192-0567-4-11

Oteman, M., Wiering, M., & Helderman, J. (2014). The institutional space of community initiatives for renewable energy: a comparative case study of the Netherlands, Germany and Denmark. *Energy, Sustainability and Society*, *4*(1), 11. doi:10.1186/2192-0567-4-11

Proença, S., & St. Aubyn, M. (2013). Hybrid modeling to support energy-climate policy: Effects of feed-in tariffs to promote renewable energy in Portugal. *Energy Economics*, *38*, 176-185. doi:10.1016/j.eneco.2013.02.013

Ragwitz, M., A. Held & J. Winkler (2014), 'Auctions for renewable energy in the European Union: questions requiring further clarification', study on behalf of Agora Energiewende, https://www.agora-energiewende.de/.

Rodriguez, A., Machado, D., & Dentinho, T. (2017). Electrical Energy Storage Systems Feasibility; the Case of Terceira Island. *Sustainability*, *9*(7), 1276. doi:10.3390/su9071276

Rothaermel, F. (2001). Complementary assets, strategic alliances, and the incumbent's advantage: an empirical study of industry and firm effects in the biopharmaceutical industry. *Research Policy*, *30*(8), 1235-1251. doi:10.1016/s0048-7333(00)00142-6

Ruggiero, S., Martiskainen, M., & Onkila, T. (2018). Understanding the scaling-up of community energy niches through strategic niche management theory: Insights from Finland. *Journal of Cleaner Production*, *170*, 581-590. doi:10.1016/j.jclepro.2017.09.144

Schot, J., & Geels, F. (2008). Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. *Technology Analysis & Strategic Management*, *20*(5), 537-554. doi:10.1080/09537320802292651

Seyfang, G., Hielscher, S., Hargreaves, T., Martiskainen, M., & Smith, A. (2014). A grassroots sustainable energy niche? Reflections on community energy in the UK. *Environmental Innovation and Societal Transitions*, *13*, 21-44. doi:10.1016/j.eist.2014.04.004

St. Denis, G., & Parker, P. (2009). Community energy planning in Canada: The role of renewable energy. *Renewable and Sustainable Energy Reviews*, *13*(8), 2088-2095. doi:10.1016/j.rser.2008.09.030

Stenzel, P., Schreiber, A., Marx, J., Wulf, C., Schreieder, M., & Stephan, L. (2017). Renewable energies for Graciosa Island, Azores – Life Cycle Assessment of electricity generation. *Energy Procedia*, *135*, 62-74. doi:10.1016/j.egypro.2017.09.487

Stenzel, T., & Frenzel, A. (2008). Regulating technological change—The strategic reactions of utility companies towards subsidy policies in the German, Spanish and UK electricity markets. *Energy Policy*, *36*(7), 2645-2657. doi:10.1016/j.enpol.2008.03.007

Stephanides, P., Chalvatzis, K., Li, X., Mantzaris, N., Prodromou, M., Papapostolou, C., & Zafirakis, D. (2019). Public perception of sustainable energy innovation: A case study from Tilos, Greece. *Energy Procedia*, *159*, 249-254. doi:10.1016/j.egypro.2018.12.058

Streek, W., & Schmitter, P. (1985). Community, market, state—and associations?. *European Sociological Review*, *1*(2), 119-138. doi:10.1093/oxfordjournals.esr.a036381

Toke, D., Breukers, S., & Wolsink, M. (2008). Wind power deployment outcomes: How can we account for the differences?. *Renewable and Sustainable Energy Reviews*, 12(4), 1129-1147. doi:10.1016/j.rser.2006.10.021

Uche-Soria, M., & Rodríguez-Monroy, C. (2018). Special Regulation of Isolated Power Systems: The Canary Islands, Spain. *Sustainability*, *10*(7), 2572. doi:10.3390/su10072572

Van der Waal, E., van der Windt, H., & van Oost, E. (2018). How Local Energy Initiatives Develop Technological Innovations: Growing an Actor Network. Sustainability, 10(12), 4577. doi:10.3390/su10124577

Weber, M. (1999). *Experimenting with sustainable transport innovations : a workbook for strategic niche management*. Universiteit Twente.

Weber, M. (1999). *Experimenting with sustainable transport innovations : a workbook for strategic niche management*. Universiteit Twente.