Thesis Research Project:

A quantitative analysis of the potential of Transition Towns for greenhouse gas reduction in Spain

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August 15, 2017

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Abstract

Both the European Union and member states such as Spain have set goals for the next years to reduce their total greenhouse gas (GHG) emission levels. A combination of technological and social innovations, including both large infrastructural and small community-led movements, can contribute. In this study, 41 sustainable energy initiatives in Spain were researched and catalogued, contributing to an online platform that details such cases in all countries across Europe. From these, an in-depth analysis was conducted to assess the impact of Transition Towns (TTs) in a novel, quantitative way. This study seeks to understand what changes are happening within TTs, what their current impact is, and what their potential for diffusion could imply. Through a combination of on-site interviews and mathematical calculations, the greenhouse gas emissions avoided through Transition programs were assessed. Many Spanish Transition Towns are very young and small, so the impact on a local level was not high. However, if extrapolated to nationwide participation in the Transition movement, it could lower annual Spanish emissions by 4%.

Keywords: Transition Towns, Transition movement, Spain, Red de Transición, ENERGISE, GHG reduction, quantitative assessment**,** peak oil, climate change, post-petroleum

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CBA	cost-benefit analysis
CO_2-eq	carbon dioxide equivalent
DECC	Department of Energy and Climate Change
EDAP	energy descent action plan
EU	European Union
GHG	greenhouse gas
IE	Industrial Ecology
km	kilometers
kg	kilograms
LCA	life cycle analysis
MLP	multi-level perspective
Mt	megatonne
TT	Transition Town
UNFCCC	United Nations Framework Convention on Climate Change
WWOOF	Willing Workers on Organic Farms

Chapter 1: Introduction

This chapter introduces the topic of Transition Towns (TTs) and contextualizes the research project with background information and statistics on the current greenhouse gas emission levels in the European Union, the reduction goals that have followed, and how the Transition movement relates to the above. The study's relevance to Industrial Ecology and its scientific contribution is underlined. The research questions are then stated, followed by the framework through which these questions will be addressed.

1.1. Background on Transition Towns

The Transition movement began in 2005 in Totnes, England, where the first TT was officially established the following year. The word "transition" in the context of Transition Towns is not rigorously defined, but it is generally taken to mean a shift away from a non-viable way of living towards a future with lower energy use and happier, fairer, and stronger communities (Felicetti, 2013). These initiatives serve to fill the gap between what the community wants and what the government provides through their organization of local programs. They can be a bridge between the bottom-up and top-down approaches, in a combination of responses whereby formal agreements and large-scale protocol can be implemented while still preserving the meaningfulness of local actions (Taylor, 2012). TTs are primarily concerned with addressing peak oil (the moment in which the highest production of oil is reached and the reduction in extraction rate ensues, implying a raise in the price of this resource) and climate change at a local level (Hopkins, 2008). At the time of the establishment of the Transition movement, peak oil was a popular topic (Hirsch, Bezdek, & Wendling, 2005) that since has become less and less prominent, while the topic of climate change has become even more relevant. In response to contextual developments, this study measures CO_2 emissions – rather than indicators for peak oil – based on the shifting emphasis of current research.

The TT movement has become one of the fastest-growing community initiatives in the world; within three years since the first launch, the worldwide count of TTs grew from 1 to 159 (History - Transition Network, 2016). It has continued to grow rapidly since, with a total of 900 TTs registered in 48 countries over the course of 12 years, including Spain in 2012 (Transition Network, 2016). While this rapid spread is impressive, it should be noted that this is only a count of the number of TTs in establishment; it does not say anything about how effective they are or how drastically levels of GHGs are reduced (or not). The movement has the potential to make an impact on the current system, but its actual contribution in quantitative terms is unknown; it is important to examine and evaluate its potency before TTs are assumed to merit environmental accolades.

1.2. Global context

To achieve GHG reductions while increasing the security of their energy supply, countries across the world have invested and will continue to invest in low-carbon technologies and energy grid infrastructure. However, studies argue that a new way of living is needed to bring about a decrease

in residential energy use; a transformation in practices oriented towards sustainability is necessary (Lenzen, Wood, & Foran, 2008; Walker & Devine-Wright, 2008). This assertion is corroborated by the Energy Roadmap 2050, which delegates responsibility for developing sustainable systems and supporting sustainable living to local organizations and cities (European Commission, 2012b). Concerted efforts to change behaviors and adopt other GHG-reducing measures are necessary to achieve this goal (Abrahamse & Steg, 2009).

Furthermore, a 2014 report on emission reduction identifies inducing changes in consumer behavior as one of the three most important ways to improve energy efficiency in the residential sector (European Commission, 2014: p. 37). For these reasons, Transition Towns that implement energy-saving and behavioral change programs should be explored as a method towards reducing greenhouse gas emissions caused by household consumption on a local scale and beyond.

1.3. European context

Energy efficiency is one of the European Union's main objectives for 2020. The world's resources for energy generation are becoming become scarcer and scarcer, and access to energy sources is becoming increasingly dependent on geopolitical considerations (European Commission, 2012a). Because of the inherent link between energy efficiency and security, planning ahead to avoid problems for future generations is necessary. In international climate talks, Europe has set a goal to reduce its greenhouse gas emissions by 20% of its 1990 levels by 2020 and by 80-95% of those levels by 2050. Because the energy sector comprises 80% of the European Union's greenhouse gas emissions, it is the most critical area for improvements. Based on an analysis of the Energy Roadmap created by the European Commission in 2011, increasing the share of renewable energy and using energy more efficiently are crucial, irrespective of the particular energy mix chosen (ibid).

It is important to study not only how large measures such as advanced energy transmission grids and top-down policies can bring about change, but also how grassroots innovations, community initiatives, and other bottom-up activities can replicate, expand, and aggregate into large total movements. In anticipating technological progress in the field of energy, the EU Reference Scenario 2013 accounts for an amalgam of factors including end-use energy efficiency and (de)centralization of renewable energy generation (European Commission, 2014a); it references the potential of sustainable energy initiatives without explicitly stating it. While models have been developed to project the impact that a singular, large-scale initiative such as a switch to nuclear energy or carbon capture and storage can have, they fail to examine the potential of smaller initiatives like Transition Towns.

1.4. Spanish context

Spain is newer to renewable energy (first integrated in 2006), but has nonetheless pledged to meet 40% of its Gross Final Energy Demand through clean energy by 2020 (Spain - Energy, 2016). It is the fifth largest consumer of renewable energy in the EU, and has encouraged a shift towards smart city and smart grid infrastructure (ibid). A stepping stone towards achieving this end goal can be the Transition Town movement: the network of TTs individually and collectively working towards a self-

reliant future (Hopkins, 2008). It is a bottom-up approach challenging traditional notions of growth and development, aided by organization at a larger level through the global Transition Network (Connors & McDonald, 2010). Beyond its infrastructure goals, Spain aims to create transferable solutions to the EU's 20/20/20 climate action goals, which include target reduction of high energy consumption, greenhouse gas emissions, and poor air quality (Spain - Energy, 2016). To achieve a change in emission levels, infrastructural changes as well as consumption patterns and behavior routines at home should be addressed.

These steps are important for both the country itself and the earth, as the 47 million Spanish residents each emit about 5.1 tonnes of CO_2-eq/year (World Bank, statistics from: 2013, updated in: 2017). A strong path to lowering these emission rates on a long-term basis is through changes in lifestyles (Lorek & Fuchs, 2011), which can be facilitated by TTs bringing people together in a more coordinated approach for a better social, environmental, and economic outcome (Connors & McDonald, 2010).

1.5. Project ENERGISE

ENERGISE is an innovative pan-European research initiative created to achieve a greater scientific understanding of the social and cultural influences on energy consumption. Funded under the EU Horizon 2020 program for three years (2016-2019), ENERGISE develops, tests, and assesses options for a bottom-up transformation of energy use in households and communities across Europe. A comprehensive review and classification of household and community energy initiatives from 30 European countries provides the foundation for the development of two Living Labs designed to capture influences on individual and collective energy consumption (ENERGISE, 2017). My role in the project was to collect and manage all data for Spain. In doing so, I catalogued 41 case studies of sustainable energy consumption initiatives, including information on organization type, funding, target of reduction, and evaluation. From this broader collection of cases, Transition Towns were selected as a category meriting further study of the quantitative assessment of efforts.

1.6. Knowledge gap

The TT movement has increased rapidly in popularity and interest, but little work has been carried out so far on the Transition Network in a way that reveals its patterns of diffusion (Feola & Him, 2016). Descriptive cases about what the Transition movement does (Hopkins & Lipman, 2009), its community and participation style (Connors & McDonald, 2010), and how it is related to localism (Felicetti, 2013) have been published. There is also investigative research about Transition Towns in the context of resilience (Brunetta & Baglione, 2013) and grassroots localization (North & Longhurst, 2013), most authors have addressed TTs from a theoretical perspective (Bailey et al., 2010; Scott-Cato and Hillier, 2010).

There is a shortage of qualitative monitoring and assessment in an empirical way, but an even more glaring lack of any effect quantification. Some works offer insight on general community-level initiatives as viable solutions for reducing environmental impacts (Scott-Cato & Hillier, 2010; Seyfang

& Haxeltine, 2012; Felicetti, 2013; Bay, 2013); however, none prescribe a certain manner for evaluation, nor substantiate if this promise is complied with.

As the Transition movement is just over a decade old, there is still a large gap in what Transition Towns are doing and what current research on the subject covers. Because the U.K. is the movement's country of origin, a fair amount of research has described these initiatives (as summarized by Felicetti [2013]). However, this type of scientific coverage is nonexistent for any TT in Spain, much less overall. Even more importantly, across the entire global Transition network, no studies could be found that attempt to quantify the effect of the TTs and their respective projects despite thorough research. This void of evaluative and numerical findings regarding the Transition movement means that the true impact of these TTs is unknown. Therefore, a quantitative assessment of the actual and potential impact of TTs is an important first step in backing the claims of the sustainability and pro-environmental action in TTs, what the present research aims to do.

1.7. Research questions

In an attempt to fill the aforementioned knowledge gap and determine the emission-saving capacity of Transition Towns, the following research question has been proposed:

> How do the collective initiatives in Transition Towns in Spain affect local levels of greenhouse gas emissions, and what could the magnitude of their contribution be on a regional and national scale?

From the overarching research question, further subquestions about the Transition Towns can be extracted:

- What changes are being implemented and supported?
- How can the effect of these alterations be quantified in terms of GHG emission levels?
- Based on the preceding quantifications, what potential does the Transition movement have in being scaled up?

1.8. Relevance to Industrial Ecology and scientific contribution

Industrial ecology (IE) systematically analyzes the interactions between human activities and the environment. It seeks to optimize the total industrial materials cycle from virgin material to finished product to ultimate disposal of wastes (Graedel, 1994: p.23). As shown below in Figure 1, its goal is to bring society from linear material flows, (a), to a full circular economy, (c). First, however, there must be an intermediate stage (b), where lies the role of Transition Towns: helping society transition from the linear model in the business-as-usual mentality, to the circular model without the use of limited resources. Through TT projects such as free exchange markets, car sharing programs, and community gardens, Transition Towns in Spain seek to localize consumption, reduce fossil fuel use, and eliminate waste.

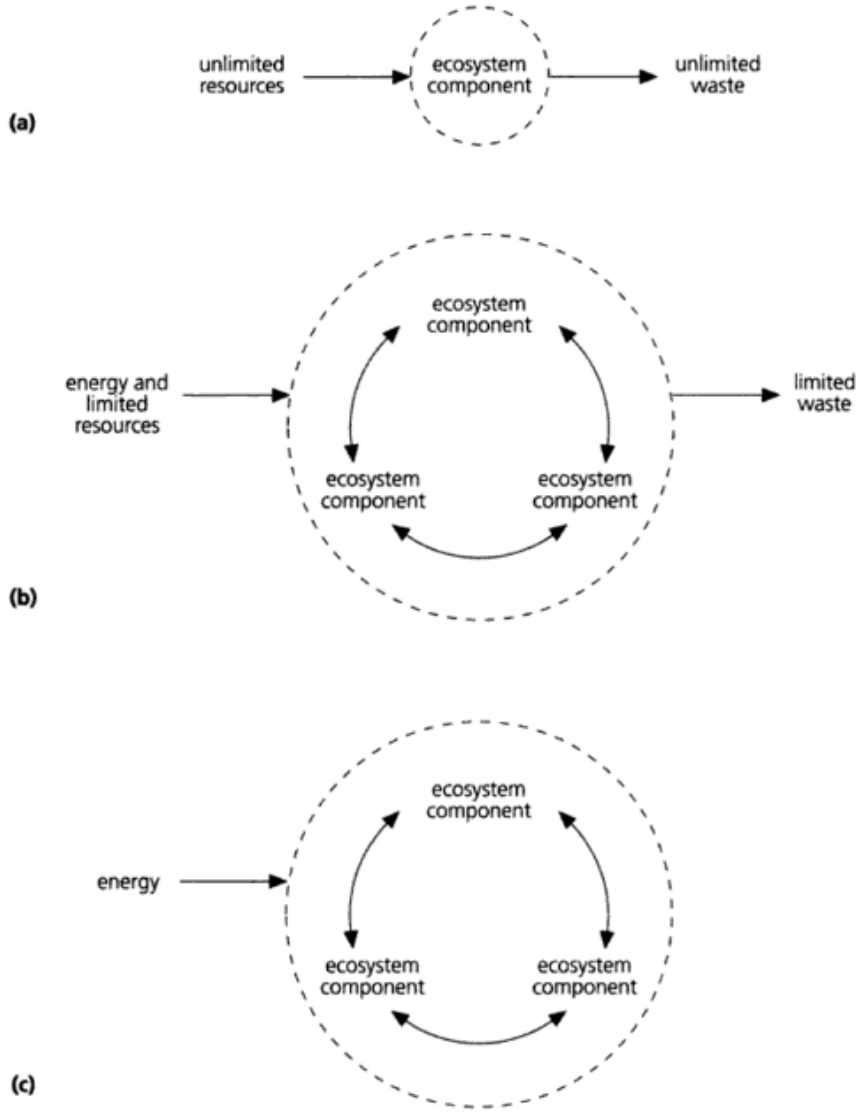

FIGURE 1: LINEAR, QUASICIRCULAR, AND CIRCULAR ECONOMIES (GRAEDEL, 1994)

The thesis topic is further relevant to Industrial Ecology in that it examines the relationship of all three pillars of sustainability: how the social aspect can directly affect the environmental aspect, and the relationship with the economic aspect. The results of this interdisciplinary study could be applied to provide a starting point and sustainable structure for program implementation from both the grassroots (bottom-up) and policy (top-down) levels in seeking to achieve goals for GHG reduction.

The present study can contribute to science by quantitatively analyzing a subject traditionally examined through a qualitative lens. Selecting the topic of Transition Towns can bring both attention and publicity to inspire others, as well as allow for evaluation of their effectiveness in terms of reducing the emissions created by individual and household consumption. In line with Industrial Ecology, this study applies a systemic approach to human problems, integrating technical, environmental, and social aspects.

1.9. Methodological and conceptual framework

To address the research questions, multiple sources of data were used during the course of the project and its embedded analysis. Field work in Spain bolstered the information gathered from online desk research to primarily answer the first research subquestion. For numbers about the energy consumption and GHG emission levels in Spain and the EU, databases were used, including: EuroStat, World Resources Institute, World Bank, CAIT Climate Data Explorer, and *Instituto Nacional de Estadística* (Spanish Statistical Office). This was supplemented by peer-reviewed literature on Transition Towns, demographic data, and emission levels. In addition to general information about a wide range of sustainable energy initiatives in Spain, a selected number of Transition Towns and their programs were analyzed in-depth, evaluated on the effectiveness of their emission-reducing potential: both proven and future. With the combination of these two broader data sources to support numerical values chosen for equation variables, more data was created from self-made calculations about greenhouse gas emissions produced and saved by the projects implemented, then converted into CO_2-equivalent terms to determine the effects of these initiatives and answer the second subquestion. Lastly, the processed and calculated data was extrapolated on a national scale to illustrate the Transition movement's influence on overall emission levels. Transition Towns were compared in their overall cumulative effect, and then scaled larger to assess their potential regional and national impact, to answer the third research subquestion. Their potential was examined through Seyfang and Smith (2007)'s three mechanisms for niche diffusion: replication at the same scale, scaling up, and translation to mainstream settings. A niche is a semi-protected space where initiatives can develop with less external pressure and are informed by, and in turn inform, concrete local projects (Seyfang & Haxeltine, 2012). Therefore, TTs relate to niche theory and diffusion, both concepts of which will be expounded upon in the literature review, Chapter 2.

This research provides suggestions for how to learn from Transition Towns about reducing emissions in a broader context. The calculations and resulting comparisons suggest which programs are most effective in reducing emissions; if a community wants to become a Transition Town, this study can act as a reference for how to put this aspiration into practice, and the best programs with which to start.

Chapter 2: Literature Review

In this section, a review of current literature on Transition Towns and their related topics is outlined. First, sustainable energy initiatives are described in a broader context, followed by information on innovations, niches, and their methods of diffusion. Then, how the results of these studies relate to Transition Towns and the reasons for topic selection are addressed. This is followed by a closer look at the functional aspects, strengths and weaknesses, and other supplementary literature on Transition Towns, for an understanding of what knowledge already exists and how it has been applied in, and added to by, this research project.

2.1. Sustainable energy initiatives

Sustainable energy initiatives emerge through social and technological innovations, and can take the form of community-level projects. These topics and the three mechanisms by which such initiatives can be diffused are addressed in this section.

2.1.1. Social and technological innovations

With Europe, the world's largest energy importer, facing continuously rising energy costs (European Commission, 2012a), it is crucial to maximize the emissions avoided by both utilizing renewable energy and by saving energy through the reuse of materials and change in behaviors. While the technology improvements and renewable energy generation infrastructure installations are necessary, they must be complemented with social innovation and lifestyle changes to maximize their full GHG-saving potential.

Because such social innovations have been shown to be very powerful in terms of sustainable development and transformation in sustainable consumption practices (Jaeger-Erben, Rückert-John, & Schäfer, 2015), sustainable energy initiatives – also in the form of Transition Towns – are important emerging concepts, yet they remain understudied in their specifics. This thesis research has zoomed in on selected examples of TTs to describe how they work and assess their contribution in the movement towards sustainable energy consumption in Spain (as part of the European Union), and to analyze their influence on greenhouse gas emissions and the potential overall systemic impact.

2.1.2. Community-level projects

The Department of Energy and Climate Change (DECC) believes in the transformative power of community-level projects on society, and therefore created the Low Carbon Communities Challenge (DECC, 2009) as one of several policy initiatives that have explicitly aimed to catalyze increased community energy activity. The goal of the challenge was to test the potential of community energy in a low-carbon energy transition, and how best to seed wider change at the community level.

Transition Towns are important for encompassing various forms of innovation through community-level projects. Current research shows that these can include everything from locally-owned renewable energy generation, to community building refurbishments, to collective behavior change programs (Seyfang, Hielscher, Hargreaves, Martiskainen, & Smith, 2014). In this way, they enable consumers to create both individual and collective change, particularly in energy consumption patterns, thereby reducing emissions created.

One obstacle in studying such community initiatives is that an overuse of the word "community" in this application has caused it to lose most meaning. As a loose basis for clarification of the term, Seyfang et al. (2014) state that community-level initiatives are "projects where communities (of place or interest) exhibit a high degree of ownership and control, benefiting collectively from the outcomes." Still, the phrase instinctively triggers a homey feeling while eluding any precise definition, even being stretched to include "communities" of industries, for example (Walker & Devine-Wright, 2008). Therefore, in this work, the word "community" will refer to the members directly involved with a Transition Town, who bond through proximity in terms of both geography and environmental values.

2.1.3. Mechanisms for diffusion, applied to Transition Towns

For green niches to spread and influence wider mainstream practices, there are three potential routes for innovation diffusion: replication at the same scale, scaling up, and translation to mainstream settings (Seyfang, 2010). As with other grassroots innovations, Transition Towns' small scale and rootedness makes it difficult for them to scale up. However, translation into mainstream settings is at the cornerstone of TTs, by developing projects which directly connect the niche to the greater community (e.g. through local exchange markets or environmental debates). This is traditionally a point of difficulty for grassroots initiatives, whose ideals often clash with the mainstream by nature (as they are usually formed to counteract mainstream developments). However, as previously mentioned, Transition Towns embody a fine balance of internal community strength, while keeping connection with the mainstream life and happenings. They are also not so distant and mechanical as would be energy cooperatives without a social base. Therefore, their values and strategy fit excellently with this mechanism for growth. This is furthered through their many educational programs, by which a bridge between the environmental activists and "regular" people in the local community is formed, facilitating discourse and information exchange between different social groups and ideologies.

Figure 2 illustrates the number and location of Transition Towns in four of the countries where they are most ubiquitous, examining current diffusion by replication:

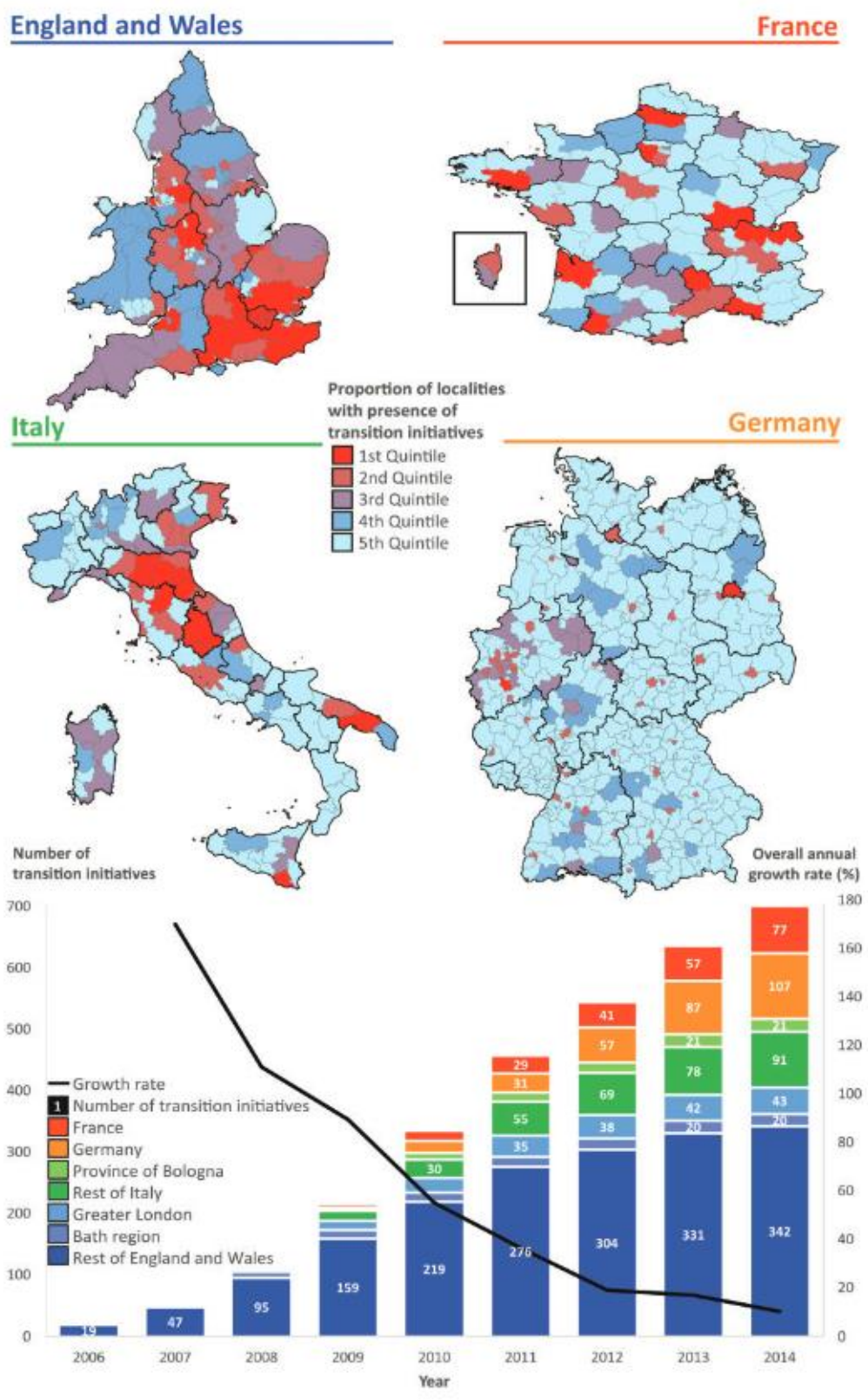

FIGURE 2: NUMBER AND LOCATION OF TRANSITION TOWN INITIATIVES (FEOLA & HIM, 2016)

As seen in Figure 2, the number of Transition initiatives in the United Kingdom, France, Italy, and Germany has steadily increased over the past eight years, but the rate of increase has slowed. These countries represent approximately 48% of all Transition initiatives within the Transition Network (Feola & Nunes, 2014). In all four, the diffusion of the Transition Network has been spatially uneven; it has little penetration in most of France, Germany and Italy, where the network has a shorter history. The graphic suggests that Transition initiatives may be more likely to emerge in some geographical areas than in others, identifies such hot- and cold-spots and calls for better comprehending where grassroots innovations emerge. This will help to uncover possible common characteristics of TTs in place and support their emergence and diffusion (Feola & Him, 2016). Therefore, with further study on the common factors underlying the sprouting of new TTs, replication will also become a viable solution for diffusion of Transition Towns. The potential for diffusion by replication, as applied to Spain's case, will be discussed in section 5.1.3, comparing their growth rate with those shown here.

2.2. Transition Towns

2.2.1. Description

The name "Transition Town" does not mean that the whole town participates and all citizens are involved; rather, it is a group of community members and local activists within the city or town that come together with a common goal. To be classified as a Transition Town, there are four assumptions involved, and 12 steps to follow. By embodying the Transition movement, it is assumed:

(i) That life with dramatically lower energy consumption is inevitable, and that it is better to plan for it than be taken by surprise.

(ii) That our settlements and communities presently lack the resilience to enable them to weather the severe energy shocks that will accompany peak oil.

(iii) That we have to act collectively, and we have to act now.

(iv) That by unleashing the collective genius of those around us to creatively and proactively designing our energy descent, we can build ways of living that are more connected, more enriching, and more cognizant of the biological limits of our planet.

(Hopkins, 2008: p. 134).

The 12 steps provide a blueprint for the TT's launch. The aim of the process is to create an energy descent action plan (EDAP) for the community. The steps are to:

(i) set up a steering group and design its demise from the outset;
(ii) raise awareness;
(iii) lay the foundations;
(iv) organize a great unleashing;
(v) form groups;

(vi) use open space;
(vii) develop visible practical manifestations of the project;
(viii) facilitate the great reskilling;
(ix) build a bridge to local government;
(x) honor the elders;
(xi) let it go where it wants to go;
(xii) create an EDAP

(Hopkins, 2008, pp. 148–175).

The Transition Town movement places an emphasis on group collaboration for change, as individual behavior change is considered too small and governmental changes are likely to be too late in mitigating CO_2 emissions; a societal transformation is required to make a true impact (Connor & McDonald, 2008; Peeters, 2012). Principles in such towns include visioning for a less consumption-driven future, inclusion of all interested parties, awareness raising about current environmental issues, resilience by building more self-sufficient cities, and encouragement of individually and collectively formed solutions. The community focuses on a goal and works across networks to accomplish it, while raising awareness about the issue's importance. They are founded on values of strong, self-reliant community building, and are posited to be better capable of managing the volatile future of climate change (Connors & McDonald, 2010). One main note is that all of this is done in a positive light; examples in practice are meant to be seen and to inspire others. The TT movement encourages positive visioning and promotes the movement not as against current wrongs, but rather, as in favor of positive change for the future (Hopkins & Lipman, 2009: pp. 7-8).

2.2.2. Functional aspects

Why Transition Towns?

Some bottom-up grassroots initiatives such as local energy cooperatives and Repair Cafés may be too impersonal if there is a lack of social cohesion embedded; their success can be inhibited if they only aim to be functional. As Walker and Devine-Wright (2008) observed, more direct and substantial involvement of local people in a project contributes to greater acceptance and support of the project at hand, and of sustainability in general. The two major manifestations of community empowerment with environmental motives are ecovillages and Transition Towns. However, ecovillages tend to have a strong spiritual focus, and are generally more geographically and socially isolated than TTs (Kilián, 2009). While this does not undermine the validity or impact of any projects, it does mean that there is sometimes a different primary emphasis and reason for gathering; in Transition Towns, the main goals of the community are sustainability-oriented (Hopkins, 2008).

Transition Towns are geographically embedded in the mainstream while incorporating outside-the-norm values, championing for environmental (as well as social and economic) sustainability. By doing so with an open-innovation and open-door policy, they are accessible to a wide population, in that any citizen with a personal commitment to sustainability can become a community member and take on the challenge to work towards a self-sufficient, post-petroleum future: the two core values of the Transition movement. While they may not be as instrumental as energy cooperatives, for

example, they represent a unique and important compromise by incorporating both practical and social elements. For this reason, TTs can be effective at building long-term resilience (one of their main goals) and have been selected as the subject of study.

Initiation and practice

The integrated approach to environmental sustainability on a community level in TTs is primed by certain factors. For example, if citizens are supportive of a local employment and trading scheme, and are generally strongly engaged in ecological, governance, and social issues, the TT has a greater chance of success from its already forged internal support (Connors & McDonald, 2010). As with any initiative, it is much more likely to become embedded when there is strong interest and enthusiasm from constituents in favor of Transition. Additionally, *Transition Handbook: From Oil Dependency to Local Resilience* – the main guide for developing TTs, written by Rob Hopkins in 2008 – helps catalyze existing sparks by providing straightforward principles for building resilient communities aimed at fighting climate change.

Transition Towns function by intertwining participation with governance. Group engagement is at their core, and inclusion is always a top priority. There is no prescribed stance for or against political issues, each TT having the freedom to choose for itself how to act (Connors & McDonald, 2010). In this way, it can garner local support while picking and choosing where it wants to create an impact. Additionally, regular interaction between people that demonstrate behavioral integrity allows trust to develop; the transformational leadership motivates people to work for the collective good (Gillespie & Mann, 2004).

In Spain

Although the TT movement has taken off strongly across the globe in recent years, in Spain, TTs are still relatively few in number. According to TransitionNetwork.org, the official website for Transition Town listings, there are currently 14 in existence across the country (although the Spanish version, *Red de Transición*, lists about 40, of which there are 10 overlapping with the central Transition Network site).

According to Juan del Río (2009), the coordinator of Spanish TTs, the Transition model is an open model, and every community involved contributes in a very important way to see what works or not, and how the model should be adapted to different scales, contexts, and cultures. The present thesis research will help facilitate the necessary investigation.

2.2.3. Strengths and weaknesses of the TT movement

The Transition movement uses the concept of resilience and has a communicative strategy and social attraction. In the context of Transition Towns, Hopkins (2007) uses the ecological definition of resilience from Brian Walker et al. (2004): “Resilience is the capacity of a system to absorb

disturbance and reorganize while undergoing change, as to still retain essentially the same function, structure, identity and feedback." Transition Towns aim to reduce the use of fossil fuels, as well as build stronger, more cohesive, and more "resilient" communities: meaning that the communities can absorb shocks and respond to them with positive change, rather than fragmenting (Scott-Cato & Hiller, 2010). Transition Towns set an example and involve people so that it is possible to see actual results of project implementations. The movement proposes a new paradigm with a global, positive message (del Río, 2009).

Beyond this, community initiatives like Transition Towns foster social sustainability by creating a sense of comradery, helping foster skills through volunteering, providing an opportunity for work experience, and improving social cohesion (About | TESS, 2016). Transition Towns facilitate project acceptance through direct benefits to the locals, and generally incorporate a dimension of education. When people surpass an information deficit and learn about the urgency and benefits of behaving in a more environmentally-friendly way, they are much more likely to welcome and support it in the area (ibid). Furthermore, TTs foster widespread public engagement through community-based activities which offer immediate benefits such as cost savings, pleasure, sociability, sense of achievement, community, and self-expression (Seyfang et al., 2012).

Despite the benefits of Transition Towns, there are nonetheless limitations in terms of their reach and scope. Transition Towns:

- Address only small sectors of society. Certain concepts such as voluntary downshifting (Hamilton, 2010) form an important contribution in affluent, over-consuming population groups, but do not yet suffice to solve system-wide problems (Lorek & Fuchs, 2011: p. 4).
- Face internal and external challenges: surviving, replicating, and spreading. It naturally is difficult to try and address structural problems with project-based solutions (Smith, Hargreaves, Hielscher, Martiskainen, & Seyfang, 2013).
- Have need for long-term resourcing and institutional support. The radical values which often catalyze and inspire niche formation can clash with commercial and policy priorities, making it difficult for some projects to receive support (Seyfang et al., 2014).
- Do not take a position in direct opposition with institutions. However, this is because the Transition network stresses the importance of TTs creating and maintaining links to local government (Hopkins, 2008).

Barriers in relationship to Spanish culture

The preceding were limitations to TTs in general; this section addresses hurdles particular to Spain. First, the *Transition Handbook* was published in English in 2008; it was translated into Spanish (*Guía del Movimiento de Transición*, courtesy of Juan del Río) seven years later, in February of 2015. This was the first book of any kind on the topic of Transition published in Spanish (del Río, 2016); it was in this year that Spaniards gained easier access to strategies in planning and tips for growth in the Transition movement. One Catalonian TT (Argelaguer) is working to translate *Energy Descent Action Plan* (also written by Hopkins), the roadmap to a sustainable future for towns, because a version in Catalan still does not exist.

One should not only take into account the difference in resources available when contextualizing Spanish TTs, but also understand the cultural setting in Spain. The interview conducted in Cardedeu during the study revealed that in Spain, the environmental movement is much behind many European countries in terms of practices, ideologies, and values. Originally from England, the interviewee stated that he estimates Spain to be 10-12 years behind the UK in terms of the environmental movement. Even in inner circles of environmentally motivated people, there is no talk of carbon emissions, measuring them, or means to lower them; the Transition group is mostly just made of people with good intentions but without assessments. Because of this unintended lack of conscientiousness, it is important to note that there are many awareness-raising projects in effect in Spanish TTs. While important to the TT movement and diffusion, the educational activities amount to zero in the GHG emission reduction results of this study.

According to the interviewee from Argelaguer, the majority of projects that are popular in Spain involve local, but especially, organic food: community gardens, consumer cooperatives, etc. There is some interest in mobility and transportation, i.e. car sharing programs. However, most initiatives are limited to these fields, leaving an opportunity for project creation and development in renewable energies, organic waste recycling, plastics, reusing/repurposing, and industrial symbioses (engaging traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and by-products [Chertow, 2000]). While this may simply be a case of a different environmental focus in Spain, it is important to raise awareness about all facets of sustainability in action, so that people understand the importance of proactivity and personal responsibility. This includes not only the burden they bear, but more importantly, the power they have as an individual and in their contribution to collective action. The Spanish TTs are a testament to this, often governed by a mere handful of people.

Compared to Totnes timeline

Because no TTs studied in Spain were more than five years old, a comparison was made with Transition Town Totnes, the first TT in the world and a benchmark for success, based on timeline equivalencies. Information about the historical progression and current status of both TT Totnes and the Spanish TTs was found on their websites during the literature review, used for comparison here.

Timeline: In Totnes, after film-showings of *The End of Suburbia* and *The Power of Community*, people gathered to interactively reflect on peak oil and climate change. Similar to many TTs in Spain, Totnes's inception also began with documentary viewings followed by meetings and discussion. However, much time has passed since this establishment in England, unlike in Spain. In 2015, Caring Town Totnes, a local network of private, voluntary, and public organizations that work together to care for the community of TT Totnes, said in a video interview that they "feel like the next 5 years are going to be really exciting" (CaringTown, 2017). They are referring to years 9-14 of being established, something the Spanish TTs are, at best, halfway to reaching. This implies that there is much to come in the later years, and that Totnes, too, had a lot of smaller projects and will develop the more exciting and impactful ones down the line (which Spain also could). In corroboration, the TT Totnes website states, "As well as the range of existing live groups and projects, the people in Transition Town Totnes have been involved in many more over the last five years" (TTTa, 2017). This

means that major participation and involvement started in 2012, six years after their inception. Because no Spanish TTs studied during this research have been around for more than five years, their positive feelings anticipating town and project growth in the near future are supported, if Totnes can be taken as a representative yardstick. The projects in TT Totnes also started with cycling, garden sharing, seed swapping, and upcycling. No quantitative data on their success or progress was available, but qualitatively in project types and timelines, Spain collectively seems to be on the same track as the most successful case example.

Projects: The TTs in Spain had an average of five initiatives each; if a similar growth rate to Totnes can be expected, they will multiply their projects four-fold in the next five years. In Totnes, there are over 20 local projects, originating from their different theme groups (e.g. for food, building and housing, business and the local economy) or from groups that have become affiliated with TT Totnes due to common aims and principles (like Cardedeu has the potential to do, merging connected groups) (TTTb, 2017). Following this, Spanish projects would expand not only in number, but in type. Currently, Spanish TTs have no housing and few business projects. By using Totnes as an example and this report for reference, they could grow to encompass other project fields as well.

In a specific example, the most updated sources show that a Repair Café in Granada – one of the TT's future projects – would be only the fifth in all of Spain, and the first anywhere in the southern half of the country (Repair Café International, 2016b). In comparison, there are already 45 in England where the benchmark TT Totnes is located (a tally of Repair Cafés in all countries can be found at the interactive map: https://repaircafe.org/en/visit/).

Events: On average, TT Totnes hosts 3-4 events per week (TTTa, 2017); the selected TTs in Spain host events about once per month. For the future, Spanish TTs could coordinate more frequent events to involve more people and increase their positive impact on the environment (if events are with the point of sustainability, e.g. vegetarian meals, free market exchanges).

Governance: Like the Transition Towns in Spain, TT Totnes is self-organizing, community-led, and mostly volunteer-operated. Projects are developed by interested members of the community coming together to make them happen, with support for communications, strategic representation, and fundraising from the TT Totnes office (TTTb, 2017). The governance structure of Totnes and the Spanish TTs is similar; they have a core group that initiates and oversees all projects. Only Granada is similar to Totnes in its expansion from this into subgroups that manage different categories of projects.

Organization and Funding: In the Totnes office, there are three part-time core staff and several grant funded project posts. Administrators and communication coordinators support the projects and promote their work and accomplishments. There are strategic and fundraising roles, as well as finance and accounting experts (ibid). While one of the features of TTs is to supplement or even counter the governing body in power, there is a lack of infrastructural and financial support in Spanish TTs that is found in Totnes. There are no finance or fundraising elects, and no paid staff. A source of income would help Spanish TTs stay on track with the timeline of TT Totnes and other successful initiatives, possibly in the form of grant funding.

Renewables: In 2012, Totnes developed a local economic blueprint: a plan for investing in renewable energy. This was six years after their establishment, supporting the claim about growth potential, that Spanish TTs may be on the cusp of rising to impact. Totnes did not have any renewable energy when it was at the stage (in years in establishment) that the Spanish TTs are in now. Easing toward this, Granada encourages contracts with Som Energia: the first renewable energy cooperative of Catalonia, established in 2010, committed to an environmentalist and strictly participatory business model (SomEnergia, 2013); Santa Coloma is prepared for its own renewables with data but lacking funding. Granollers also is developing a backcasting regime whereby they design a roadmap for accomplishing small milestones in progression towards their ultimate goals for 2030. While not gathered as explicit information, it is reasonable to assume that this includes some transition towards, or incorporation of, renewable energy. Perhaps asking the TTs about it during this research planted a seed, which could be the catalyst for them also developing a plan for renewable energy if it had not been considered before.

Based on the above comparisons, the potential of Spanish TTs to make an impact – especially if given time to develop – appears to be viable, which is what the present research set out to investigate. The process for doing so is described in the following section.

Chapter 3: Methodology

In this chapter, the core methodology is outlined, incorporating the project framework and describing the approach for reaching quantitative impact results.

During the study, 41 cases of sustainable community energy initiatives in Spain were found through desk research, including sources from online Spanish interviews, reports, and article publications. They were cataloged according to size, objectives, funding allocation and source, outputs, timeline, resources committed, initiator, areas of consumption targeted, medium of intervention and type of change, basis in information or interaction, and incentives offered. The full list and further qualitative details about each can be found in Appendix A.

From these, the subgroup of initiatives selected for further study and in-depth analysis was decided to be Transition Towns. While there are certain norms and regulations that must be adhered to qualify as a true Transition Town, it was not possible to verify point by point remotely if these were met; for this reason, a listing on either the general or Spanish Transition Network websites was used as the criterion for inclusion of in-depth study during the thesis project. In an attempt to garner the largest possible sample size, every Spanish TT listed on either of the network websites with an email, phone number, or avenue of communication otherwise was contacted (n=36). Five of these were from the original 41 sustainable energy initiatives of the broader research, and confirmed requests for in-person interviews: (1) Granada, (2) Santa Coloma de Queralt, (3) Cardedeu, (4) Granollers, and (5) Argelaguer (see Appendix B for further information). Granada is in the Andalusia region of Spain, and the remaining four are clustered around Barcelona and Girona. For visual clarity, they have been flagged on a country map in Figure 3, numbered respective to the aforementioned list.

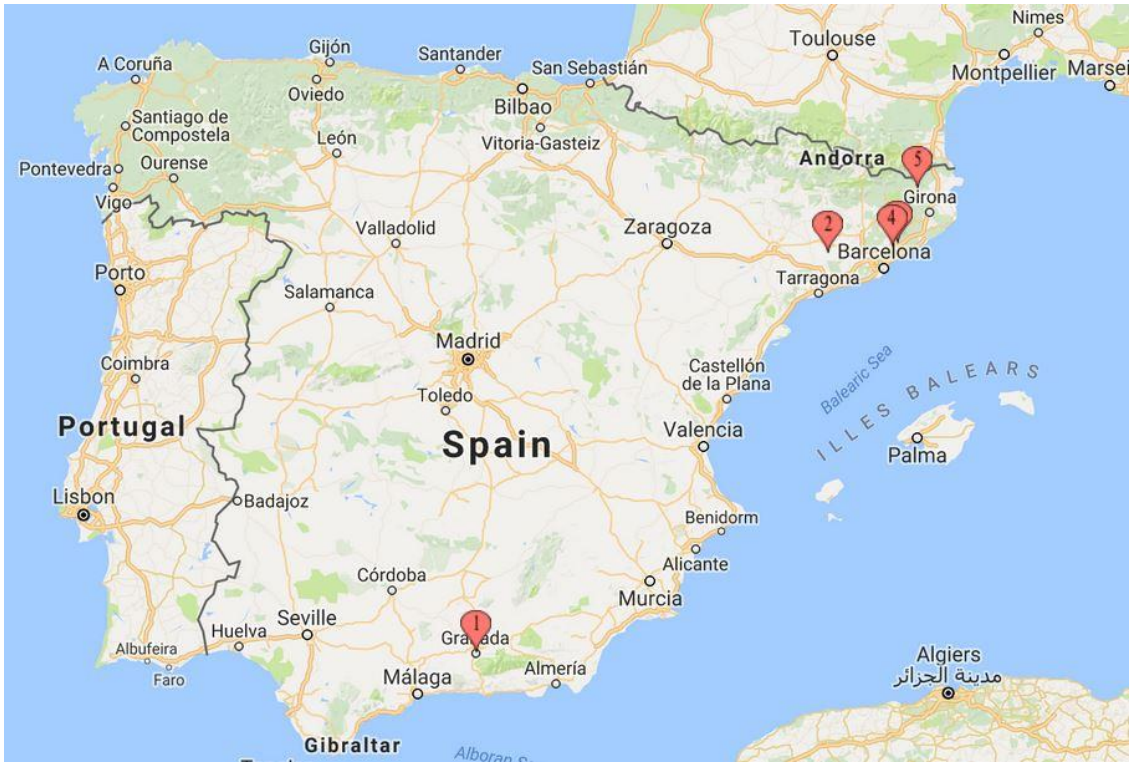

FIGURE 3: TRANSITION TOWNS INTERVIEWED: LOCATION (GOOGLE MAPS, 2017)

This array of TTs is advantageous for study, as it includes some variability in region and therefore sub-climates and subcultures within Spain; moreover, the concentration of TTs studied in Catalonia gives a decent sample size for making assertions and extrapolations about regional data and impacts.

For each Transition Town confirmed for further study, a provisionally comprehensive table of programs implemented (both behavioral and infrastructural) was created from online research to compare and contrast all selected TTs on a qualitative level. Visits to each selected TT were then scheduled to examine their niche group culture, programs, and rituals, by interviewing leaders of the group about energy and general consumption, and how this is affected by their values and programs. The purpose of these interviews was to gather further information: both qualitative – additional programs that have been implemented but not yet posted online, background to the decision-making as to why one program was selected over another, etc. – and quantitative – to insert values into equations made by the researcher to assess the greenhouse gas emissions avoided through each program and greater TT. In essence, through field work, qualitative information was collected and then quantified to assess what kinds of changes were made and what their effects were in terms of energy and emission reduction.

Because data on emission changes in response to the programs does not exist, formulas were constructed to translate the method of intervention into an estimated numerical value (e.g. If one community garden is created, it avoids X quantity of emissions). The emissions savings per year were evaluated: according to each program, and in a compilation of all programs' savings to assess the total effect of each TT.

There was no information on CO_2 emissions for the TTs or the cities themselves; therefore, the best available data and calculation methods were used. Through a combination of on-site interviews, a literature review, and statistical databases, quantitative information was sought. Where it was not found, qualitative information was gathered and then transformed into quantitative information by pairing it with additional sources. For those programs which changed practices in food (including production, consumption, and preparation), transportation, or heat and energy generation, the TESS Track-It! tool was used to convert the raw numbers (e.g. kg of locally grown vegetables) into emissions saved by the program (i.e. kg CO_2-eq) through pre-made calculations. TESS (Towards European Societal Sustainability) is a research project exploring the role of community-based initiatives in transitioning to a sustainable and low-carbon Europe. Track-It! is an online tool developed by these researchers to allow initiatives to estimate the greenhouse gas emissions avoided through their activities in the domains of food, energy, waste, and transportation (Track-It! Tool, 2017).

For any results that could not be translated by the tool, equations were created and solved by the researcher. This included the calculations for aquaponics systems, Repair Cafés, local and free exchange markets, wood oven use, energy avoidance from natural heat, and all intermediary equations needed to elicit the results input into the tool.

After calculations were completed, a table was created for each Transition Town, detailing their programs, the program's individual contributions, and the TT's overall cumulative impact (by totaling

the program impacts). Looking at all tables, reflections on the most effective TT programs and towns, in terms of highest reduction of emissions, were made.

The potential impact on a national scale was then examined through extrapolation to a scenario involving 100% of people in Spain in the movement. The calculated average emissions saved per capita in the TTs were multiplied by the population of Spain to elicit national estimates and implications. This sum was compared to other countries' yearly emission levels for reference of magnitude. Then, what could be learned from about lifestyles, trends, technology, and policy at a national level was described. The same was done on a regional level, excluding Granada results, to see how TTs affect Catalonia's emissions (proportional to the population and impact).

Based on these results and conclusions, recommendations for prospective TT initiators about the best programs in terms of emissions reductions with which to start, and for current TTs about the best way to progress, were made. A table of all programs ranked in descending order of GHG emission reduction was created to compile results in a way that would facilitate program suggestions at a glance. The results could also be used to inform policy makers looking to invest or change regulations in favor of a sustainability project. Finally, recommendations for future research were made.

For further illustration of the methodological process, the flow chart on the following page was created:

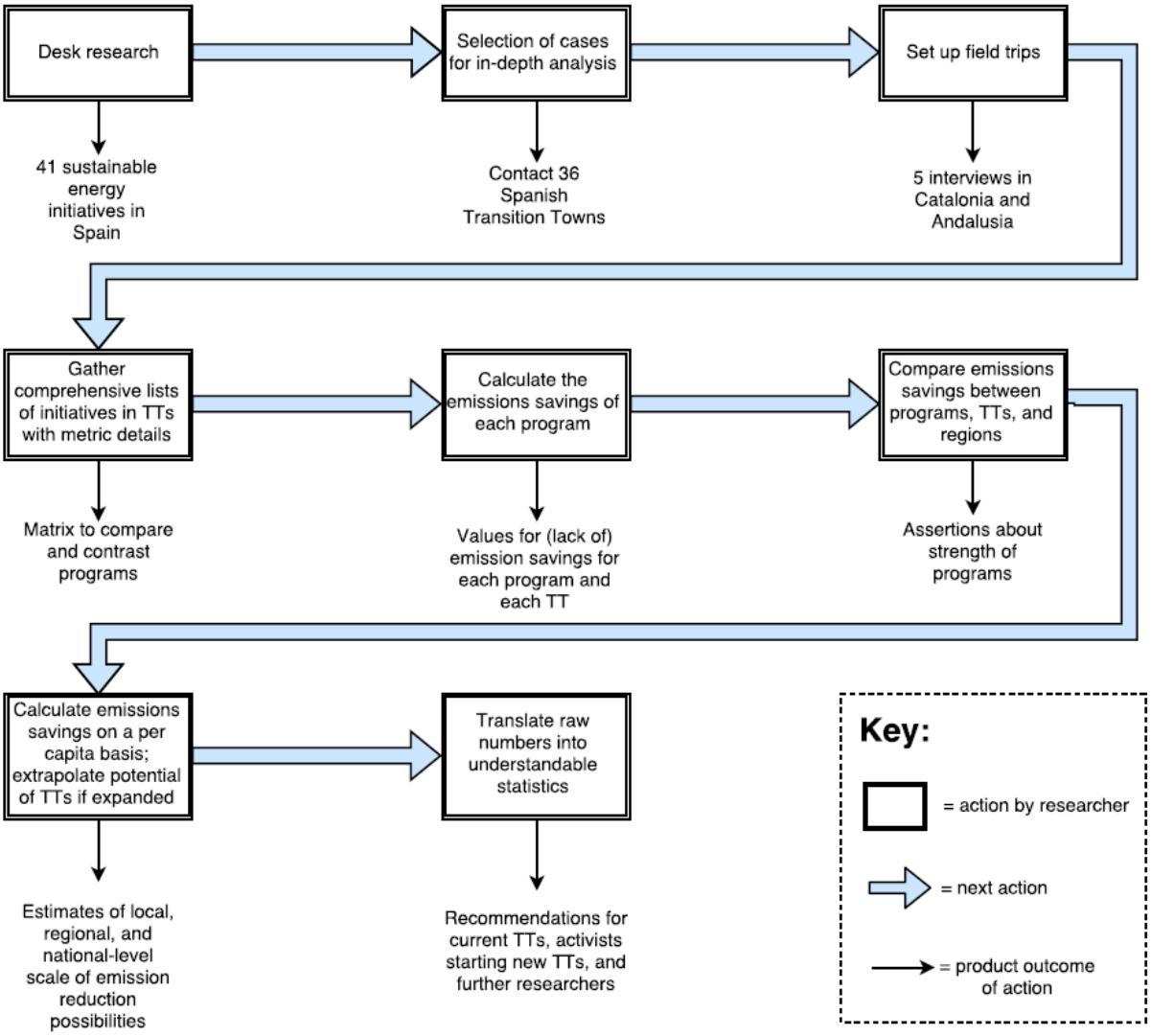

FIGURE 4: METHODOLOGY FLOW CHART

For in-depth explanations about how each value was calculated, see Appendices C and D.

Chapter 4: Results

The following tables contain the estimated GHG emissions avoided in the Transition Towns studied and visited in Spain. The tables detail each project's estimated GHG savings per year, in CO_2-equivalent kilograms. All per capita-equivalencies have been rounded to the nearest whole percentage; all kg CO_2-eq/year greater than 10 have been rounded to the nearest ten. The exactness of these numbers according to decimal place does not reflect the degree of certainty of the value. In all calculations, the general assumptions outlined in Appendix C apply. All project titles are translated to English for a better idea of what the project involves (with their given Spanish or Catalan title following for thoroughness); each will be referred to by their English name for the rest of the report. The TTs will be referred to by their official names, "en Transición" in Spanish and "en Transició" in Catalan both meaning "in transition."

Many projects and events are organized to spark interest, inspiration, and awareness in citizens, e.g. debates on environmental topics, documentaries, and guest lectures. Bringing in international speakers has been shown to give people pride and realize the topic is important (North & Longhurst, 2013). Therefore, the projects are critical for the movement's growth and support, but had to be reduced to a "zero" value according to calculations. Those Transition projects which strengthen the movement and sustainability in general, but which cannot be interpreted through a mathematical equation, are included in the subsections labeled "Excluded projects."

4.1. Granada

Granada is a city of 234,000 (City Population, 2016), with 23 official Transition members. It is located in Andalusia, 4.5 hours by car directly south of Madrid. This group of motivated volunteers has united in hopes of transitioning to a post-petroleum future. Information about their ongoing and future projects can be found at: https://granadaentransicion.wordpress.com/proyectos-en-transicion/. To learn more about the initiative, a face-to-face interview was conducted by the researcher on May 18, 2017, in Granada.

The idea for this initiative emerged in 2012 from people living in Granada committed to making a change, and looking for more people that also saw the need for this change, who valued the power of a community and would unite in a collaborative and solidary manner in search of a way to live a more responsible life. They have learned from other successful Transition Towns, having been visited by the initiators of the TT movement, e.g. representatives from Totnes, as well as Juan del Río (the co-founder and coordinator of the Spanish Red de Transición), who organized lectures and workshops to support and encourage the growth of Granada en Transición.

4.1.1. Granada: Included projects

Those projects which have been included in the calculations for Granada en Transición are shown in Table 1.

TABLE 1: GHGS AVOIDED BY PROJECTS IN GRANADA

Project	Estimated avoided kg CO_2-eq/year	Equivalent to ___ of annual average per capita emissions in Spain
Happy Chicken Coop	200	4%
Kitchen in Transition	80	1%
Aquaponics System (irrigation)	-60	-1%
Aquaponics System (local, organic food)	10	0%
Community Garden	30	1%
Repair Café	210	4%
Total impact (current):	**250**	**5%**
Total impact (with future estimation):	**460**	**9%**

Happy Chicken Coop (*Gallinero Feliz*)

Fifteen families have chicken coops to produce local, organically-raised chicken eggs. The avoided transportation from farm to store to home (consumed on-site) saves approximately **200 kg CO_2-eq/year**, equivalent to **4%** of an average Spaniard's total yearly emissions.

Kitchen in Transition (*Cocina en Transición*)

Every month, members of the Transition group in Granada come together for a social evening to share a meal, prepared vegetarian for environmental purposes. With an average attendance of 15 people per event, this avoids **80 kg CO_2-eq/year**, equivalent to **1%** of average per capita yearly emissions.

Urban Self-sufficiency (*Autosuficiencia urbana*)

The overarching goal of this initiative is to achieve urban self-sufficiency (in facets including food, energy, and waste). This naturally involves many sub-projects, which are, in large part, still in the development or even idea phase. The only one which has been physically implemented is that of Aquaponics Systems (*Sistemas Acuapónicas*). It is a two-part symbiotic system for producing both

fish and vegetables simply and organically. Rather than using synthetic fertilizers, fish excrement is broken down by bacteria and used to nourish the plants in the mutually beneficial system. After absorbing the nitrates and effectively filtering the water, it is returned to the fish tank. In the case of Granada, the pump that creates this circulation is active 24 hours a day. For further illustration of a simple, small-scale aquaponics system and how it functions, see Figure 5 below:

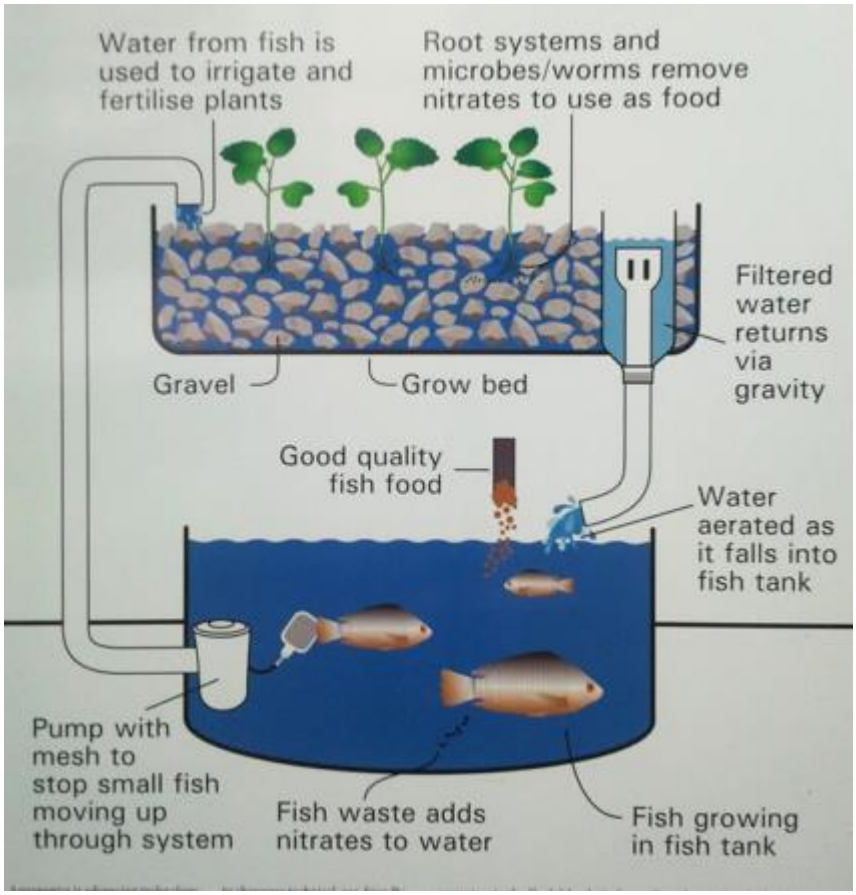

FIGURE 5: A SIMPLE, SMALL-SCALE AQUAPONICS SYSTEM (OKEMWA, 2015)

By way of the local food produced by the aquaponics system, very little impact on emissions levels has been made (avoiding **10 kg CO_2-eq/year**). In fact, the energy required for the system's operation outweighs its benefits (**-60 kg CO_2-eq/year** to operate leads to a net of **-50 kg CO_2-eq/year**), if speaking exclusively in terms of GHGs avoided. The reason for this is the low output of food, yet a large energy sum for the pump. Even still, this overall *negative* impact is also extremely small, whose absolute value is about **1%** of an average Spaniard's emissions.

Community Garden (*Huerto Comunitario*)

This is a small vegetable garden for educational purposes that grows tomatoes, peppers, and onions. From this garden maintained by the community, about **30 kg CO_2-eq/year** is saved from being emitted into the atmosphere, about **1%** of what a person emits overall per year.

Repair Café (*Reciclería*)

The latest project in development in Granada is modeled off of Repair Cafés; it will help people fix electronics and mend textiles, rather than buying new ones. It is not yet in effect for them to have concrete details and measurements, but the plan is mature enough (a few months away from an official launch) to know that it will be similar to other standard Repair Cafés, so it was possible to create an estimate of the GHG emissions it will save in the near future. Therefore, this estimate has been included in Table 1; however, the project has not been figured into the current total estimated amount of yearly GHG emissions avoided by the TT (as it is not yet in existence). In any case, it is relevant to include for discussion purposes later and evaluation of the TT's future potential. The average CO_2-eq/year avoided per café was estimated based on external reports (Repair Café International, 2016a; TNO & Postma, 2016), then used for a projection in Granada: about **210 kg CO_2-eq/year**, **4%** of a Spaniard's yearly emissions.

Total

In the cumulative impact of all ongoing Transition projects, Granada avoids **250 kg CO_2-eq/year**, about **5**% of what one average Spanish person normally emits.

4.1.2. Granada: Excluded projects

According to the interview, the garden's produce is a reason to get together in the outskirts of the city and learn more about gardens; it is not intended to be a very agriculturally-productive endeavor. Therefore, while the project is quantifiable in terms of GHG emission avoidance, the resulting number does not show its full value.

In this respect, TTs may now serve to fill the social role that churches did previously. A landmark study of the social aspects of churches by Glock, Ringer, and Babbie (1967) called attention to the fact that church was an integral component of a social support network for some. Other projects supporting this theory include Transition Dancing (*Baile en Transición*), where people simply gather to dance together in Granada, without any environmental motive. As the days of going to the local church for social gatherings and support are phasing out in Spain, Transition Towns have the capability of filling this role. Therefore, it is not only an environmental void from the government or institution that the Transition Towns fill, but also a social one for connecting people and helping them live more harmoniously in an expansion of their community and social network.

Granada also offers Transition Movies (*Cine en Transición)*, whereby environmental documentaries are screened for the community, inspiring and educating the viewers. They host Transition Debates (*Debates en Transición)*, through which a selected topic within the field of sustainability is brought to the table and debated from both sides. This brings fuller understanding and knowledge to light for those who may have otherwise only formed their opinion on the subject from sound bites and hearsay. These strengthen the social pillar of sustainability and are beneficial for all parties involved, yet have no (direct) influence on greenhouse gas emissions and therefore could not be factored into the equations. However, their value is outside of environmental confines. Similarly, the local chicken

coops in Granada make a stand for animal welfare by treating the chickens properly and giving them a truly – not just legally – free-range coop.

Composteras is the next project in formulation at Granada en Transición, to establish a composting program, anticipating implementation of about 20 receptacles. This was not quantified in the research because it has not started and too few variables were known. Secondly, there is conflicting research on the effects of composting based on the amount of time after disposal it is evaluated. One researcher claims that home composting bins may produce more GHGs per unit of waste than landfilling (Hutton, 2009). According to this study, composting does reduce the amount of waste going to landfill and in the long run may reduce GHG emissions; however, it takes more than three decades for greenhouse emissions from landfill to catch up with those from aerobic composting. It also may increase in salt and heavy metal content in the soil (Hargreaves, Adl, & Warman, 2008). However, it improves soil aggregation and stability (Diacono & Montemurro, 2010), as well as improves biological activity (Bastida, Zsolnay, Hernández, & García, 2008; Hargreaves et al. 2008) and nutrient availability for plants (Boldrin, Andersen, Møller, Christensen, & Favoino, 2009). Without seeing it in practice and being able to make observations of the compost project, it is impossible to make an accurate estimate of the environmental impact it will have in Granada.

4.2. Santa Coloma

Santa Coloma de Queralt is located in Catalunya, Spain, about 1.5 hours by car northwest of Barcelona, with about 2700 citizens (City Population, 2016). A group of motivated individuals concerned with fossil fuel dependency and the changing climate came together with the goal to make a positive difference. Their website (in Catalan) can be found at: http://santacolomaentransicio.blogspot.nl/. The information following which could not be gathered from their site was supplemented by a face-to-face interview on May 22, 2017, in Igualada, the city of the interviewee's workplace (university).

The idea for this initiative emerged in January 2012 and used TT Totnes as a model for development. They are in contact with the university in Igualada and invite internationals to volunteer annually to revitalize a natural area in the village. It officially took off in April 2012, when more than 150 motivated people gathered at a meeting where Santa Coloma en Transició was presented. June 2012 saw the first meetings of working groups; there are now about 10 members actively involved in projects.

4.2.1. Santa Coloma: Included projects

Those projects which have been included in the calculations for Santa Coloma en Transició are shown in Table 2 below.

TABLE 2: GHGS AVOIDED BY PROJECTS IN SANTA COLOMA

Project	Estimated avoided kg CO_2-eq/year	Equivalent to ___ of annual average per capita emissions in Spain
Car sharing	3500	69%
Local markets	700	14%
Social garden	460	10%
Total impact (current):	**4200**	**83%**
Total impact (with future estimation):	**4660**	**92%**

Car Sharing (*Compartir Cotxe*)

At first, this project was met with much success. An online platform akin to BlaBlaCar for posting and requesting rides to other cities was established; a Twitter account also listed the opportunities in addition to the website. The program encompassed even those who were not officially a part of the Transition group. Around 15 rides were shared per week: most going to Igualada for work, and a few with destination Barcelona or Tarragona. Because the town is so small and close-knit, people may see each other on the street and arrange rides in person now, as it is easier and more personal than trying to log in online and establish the ride connection through a technological method. Therefore, the electronic trace of most of these rides has disappeared. However, people who share a ride to work, for example, might have met through the website for the first time and then stayed in contact informally over calls or texts if they knew they could continue to carpool (rather than reconnecting through an external third party over and over). Therefore, an assumption made is that the original prevalence continued informally without much change over time, although unaccounted for on the website. Based on this, it was estimated that the program saves **3500 kg CO_2-eq/year**, that of about **40%** of one person's annual emissions. To check for influence by the researcher in this assumption, a sensitivity analysis was conducted (detailed in section 4.6.2.).

Local Markets (*Mercats Locals*)

At markets held twice a year in the town square of Santa Coloma, citizens sell their own local products: from food (cheese, bread, jam) to gardening things to various hand-crafted artisan items, with 20-30 venders who each make a few hundred euros. Since everyone is assumed to bring their items to and from the market on foot (a small town where the center is accessible for all pedestrians), GHG emissions from transportation can be avoided, which is what primarily accounts for the **700 kg CO_2-eq/year** that the two markets together avoid emitting (by producing and consuming locally) – an equivalent of **14%** of one average person's annual emissions.

Social garden (*Hort Social*)

The social garden project would grow crops for social and environmental benefits; it would create a space for neighborly congregation, as well as allow the lower-income residents who cannot afford good produce to enjoy it during harvest season. It is still in the planning phase; therefore, it has not been figured into the TT total. However, based on the planned garden size and crops, an estimation of **460 kg CO_2-eq/year** (**10%** of a Spaniard's yearly emissions) was made to project its effect.

Total

Through the cumulative impact of all its Transition projects, Santa Coloma avoids over four tonnes (**4200 kg**) **CO_2-eq/year**, close to what one person emits on average per year (**83%**).

4.2.2. Santa Coloma: Excluded projects

In Santa Coloma, there is an annual seed exchange with six successful editions thus far. This offers an ecological benefit to the community by improving biodiversity in the area, yet cannot be measured on a basis of emission level impact with the information given. There is also a very successful yearly international volunteer project, whereby teens and young adults come from Spain and abroad to revitalize the natural areas overrun by brush on the town's nearby river. While this project benefits the environment in some way, it is more about social benefits and doing good deeds.

The same principle philosophy about the community garden at Granada applies to Santa Coloma's local saffron project (*Safra Local*), in which they aim to create a local brand of saffron. It has been one of their most important crops for hundreds of years, revitalized in recent decades to bring the culture back, breed seeds that are specifically suited to the hyper-local climate, and create a steady yield of locally- produced and consumed saffron. While the project of rejuvenating the growth of saffron in the area has been going on for over five years, the jump to a local brand is still in the inception phase. Therefore, only about 0.5 kg of saffron are produced per year, making a negligible effect on emissions and so was excluded. However, the project goal is less about the actual annual production (which is what was measured in this study), and more about the idea, the establishment of a local brand, pride for their town, and satisfaction in having created their own product.

4.3. Cardedeu

Cardedeu is a town of 18,000 inhabitants (City Population, 2016) in the outskirts of Barcelona, 45 minutes by car from the larger city's center. There are about 10 active members in the Transition group. More information can be found on their website: http://cardedeuentransicio.wordpress.com/, where links are also provided to connected organizations. To understand the initiative more fully, a face-to-face interview was conducted on May 23, 2017, in Cardedeu.

The idea for this initiative began in 2011 when a group of people visited Transició Vilanova (Vilanova I la Geltrú, a town situated between Tarragona and Barcelona, also part of the Transition

movement), sparking local interest. The co-founder and coordinator of the *Red de Transición*, Juan del Río, lives in Cardedeu and works on behalf of the local Transition group. Besides learning from lectures and workshops, Cardedeu en Transició has grown by modeling off of Transició Vilanova even beyond the initial inspiration.

In its beginning in 2012, Juan del Río presented a Transition documentary. Growing from there, in 2013, the school EsBiosfera had the first meeting, inviting anyone interested in learning about and participating in Transition. That November, the Transition Town was officially born, collaborating also with Mathieu Durrande (a French researcher and expert in management, waste engineering, and circular economy).

4.3.1. Cardedeu: Included projects

Those projects which have been included in the calculations for Cardedeu en Transició are shown in Table 3.

TABLE 3: GHGS AVOIDED BY PROJECTS IN CARDEDEU

Project	Estimated avoided kg CO_2-eq/year	Equivalent to ___ of annual average per capita emissions in Spain
Community Garden	5	0%
Free Pickings	5	0%
Total impact (current):	**10**	**0%**
Total impact (with future estimation):	**10**	**0%**

Community Garden (*Hort Comunitari*)

A community garden of six box plots was recently established in Cardedeu with tomatoes, peppers, lettuce, onions, leeks, and green beans, among others. The local growth and consumption of these is expected to save about **5 kg CO_2-eq/year**, which is less than 0.5% of the average per capita emissions.

Free Pickings (*Collites Gratuïtes*)

The local fruit-bearing trees accessible to the public around town were mapped electronically, for anyone to view the nearest-located bush or tree at a glance where they can pick free, local food. Additionally, because of the small town size, all are accessible to anyone by foot. Still, based on the estimated yearly harvest, the total emissions avoided are **5 kg CO_2-eq/year**, also lacking enough impact to register as a significant proportion of annual per capita emissions.

Total

The total estimated emissions avoided from these two projects is about **10 kg CO_2-eq/year**, excluding all projects that, although initiated and maintained by some of the same heads of Cardedeu en Transició, have been done through separate but linked organizations, and therefore do not technically fall under the umbrella of Transition for the purposes of these calculations.

4.3.2. Cardedeu: Excluded projects

In Cardedeu, there are two slow-food restaurants, which operate based on using only local and wholesomely prepared food. They are in service from April to October, using solar ovens to cook and also hosting self-sufficiency workshops. These classes have attracted 1960 "students," offering instructions on making home repairs, sewing clothes, gardening, and more. This is done by the individuals involved with Cardedeu en Transició, but through another organization, so the benefits could not be attributed to Transition.

They also have a local currency to keep economic strength in the city, but there was no way to evaluate if or how this affected GHG emission levels.

Cardedeu's Consumption Map (*Mapa de Consum*), Figure 6, is an interactive online map with corresponding spreadsheets whereby all organic and local carriers, as well as second-hand shops, are listed to promote and facilitate responsible, yet close (within 20 km of Cardedeu) and easy, consumption. However, there was no way to determine how many people visit the shops for having seen this tool on the Transition website or how much they buy, so it was excluded from calculations.

FIGURE 6: MAPA DE CONSUM (CARDEDEU EN TRANSICIÓ, 2015)

4.4. Granollers

Granollers is a city of about 60,000 (City Population, 2016) very close to Cardedeu with 14 official Transition members, located 45 minutes north of Barcelona by car. This group of motivated volunteers united in hopes of transitioning to a post-petroleum future. Information about their group, with updated article publications about their ongoing activities, can be found at: https://granollersentransicio.wordpress.com/. To learn more about the initiative, a face-to-face interview was conducted on May 24, 2017, in Granollers.

The initiative began in 2013 with a group of people who wanted to decrease their consumption. They have learned from other successful Transition Towns, but are also paving their own way by creating a backcasting plan for how they envision Granollers in an ideal future 13 years from now.

4.4.1. Granollers: Included projects

Granollers en Transició did not have official names for the projects already, so an English label for each has been created. Those projects which have been included in the calculations for Granollers en Transició are shown in Table 4.

TABLE 4: GHGS AVOIDED BY PROJECTS IN GRANOLLERS

Project	Estimated avoided kg CO_2-eq/year	Equivalent to ___ of annual average per capita emissions in Spain
Organic Garden	180	4%
Free Exchange Markets	2420	48%
Consumer Cooperative (fruits)	490	10%
Consumer Cooperative (vegetables)	2120	42%
Bike Delivery (library)	110	2%
Bike Delivery (packages)	740	14%
Total impact (current):	**6060**	119%
Total impact (with future estimation):	**6060**	119%

Organic Garden

This garden is similar in concept and execution to the other TT community gardens (i.e. in Granada, Cardedeu, Argelaguer, and eventually Santa Coloma). They grow typical crops of the season, producing local vegetables for community members. The combination of avoided fertilizer and

avoided transportation saves Granollers from emitting **180 kg CO_2-eq/year**, **4%** of an average Spaniard's yearly emissions.

Free Exchange Markets

At the free exchange markets in Granollers, there are tables set up in an open-market fashion where people can bring their lightly-used, no longer needed items (primarily clothes) for someone else to claim and give a second life. Through this manifestation of sharing economy (by passing individual ownership for free and essentially co-owning over the product's life span, rather than the full-time shared ownership of products found in traditional sharing economy [Cohen & Kietzmann, 2014]), emissions are avoided in every part of the life cycle of the products (in the reuse of items diverted from landfills, as well as the avoided consumption of what would have otherwise been purchased as a new product). For this reason, literature on life cycle analyses was used to quantify this, as described in Appendix C.

By assuming that all items brought are clothes, or a carbon-equivalent item, and have 50% of their life left, the calculations made take an average of the LCAs for each respective article of clothing and divide the results in half. Based on the number of tables and types of clothing said to be present gathered from the on-site interview, an estimation was made about how much of each clothing type was there, then finding the kWh avoided according to the averages made from the LCA, multiplied by the emission factor for Spain's electricity mix. The results came to **2420 kg CO_2-eq/year**, or the equivalent of **48%** of the per capita yearly emission level in Spain.

Consumer Cooperative

There are 250 families involved in the Granollers Consumer Cooperative, a store that sells produce and other alimentary items from the closest possible source. "Local" can be understood differently, so here the distance from the popular idea of the "hundred-mile diet" (160 km) from Smith and MacKinnon (2007) was used. Although the products carried by the store sometimes come from as far as the Canary Islands for bananas or Valencia for oranges, the majority of products come from much less than 160 km away. Therefore, it was assumed that the average distance of all of the products sold in the cooperative was from within 160 km. This was estimated to save **2610 kg CO_2-eq/year**, **52%** of one person's yearly contribution to greenhouse gas emissions.

Bike Deliveries

In Granollers en Transició, there are two separate but related bike delivery programs. The TT takes advantage of its small town size, and therefore bike-able errand-running city distances, by substituting traditional fossil fuel-consuming work vehicles with bike transportation of goods.

The first of the two initiatives substitutes library vans that normally transport the books between locations with bikes. After a year of doing so, the Transition members avoided a total of **110 kg CO_2-eq/year** (according to their own calculations, gathered during an on-site interview)**.** The second involves a biking group that gathers every Monday, Wednesday, and Friday of each week to move packages around town (all distances of about 1-1.5 km), instead of the last leg of delivery in a large

motorized vehicle. Taking this action saves **740 kg CO_2-eq/year** (also according to their calculations). Together, these two bike substitution efforts save **16%** of one person's annual emissions.

Total

The combination of all the ongoing programs in Granollers saves **6060 kg CO_2-eq/year**, more than one full Spaniard's total yearly emissions (**119%**).

4.4.2. Granollers: Excluded projects

In Granollers, the principal function of its community garden is to attract visits from schools and civic centers to spread the idea of sustainable agriculture. This supports Granada's perspective towards the social garden; here, it is also a symbolic initiative to bring people together and promote sustainable causes, not necessarily to create a high product output. Therefore, the calculated numbers again do not convey the effect of the primary intention; they only measure a secondary by-product.

The Transition group is also working on "Granollers 2030," a backcasting plan to shape the city step by step into how they want it to be in 13 years. They are presently in the planning and development phase. Eventually, it should lead to large emission reductions (particularly in the long run, and hopefully through small projects as building blocks in the short-run), yet there was no way to estimate its potential effect at the present time. Nonetheless, it is important to notice the step towards making such a plan, for demonstrating a focus on long-term goals and end results and an evolution of thinking.

4.5. Argelaguer

Argelaguer is a small town of 400 people (City Population, 2016), with 20 members involved in projects in some form. It is located in Catalonia 40 minutes north of Girona by car. Information about their past, ongoing, and future initiatives can be found at: https://argelaguerentransicio.com/iniciatives/.

It is a non-profit initiative that began with a small group of 4-5 neighbors in 2012. Their objective is to create a stable group of people who become responsible consumers and citizens in terms of food, energy, economy, transportation, education, and politics. They encourage proposals to help advance the world towards a future of degrowth and low energy consumption in all of the aforementioned areas.

To learn more about the initiative, a face-to-face interview was conducted along with a walking tour of the projects in the TT on May 26, 2017, in Argelaguer.

4.5.1. Argelaguer: Included projects

Those projects which have been included in the calculations for Argelaguer en Transició are shown in Table 5 below.

TABLE 5: GHGS AVOIDED BY PROJECTS IN ARGELAGUER

Project	Estimated avoided kg CO_2-eq/year	Equivalent to ___ of annual average per capita emissions in Spain
Open Oven	90	2%
Community Garden	310	6%
Chicken Coops	110	2%
Festival of Giving	1210	24%
Car Sharing	3250	64%
Natural Heat	340	7%
Total impact (current):	**5300**	104%
Total impact (with future estimation):	**5300**	104%

Open Oven (*Forn obert*)

Every month, the leader of Argelaguer en Transició gives an open invite for any community members to come over and cook in his wood stove to avoid using their traditional gas or electric oven or stove. It is in use all day, starting in the morning with baking bread and pastries, all the way till the evening, cooking meat and vegetables. The estimated emissions avoided from this monthly cooking alternative are **90 kg CO_2-eq/year**, **2%** of average Spanish per capita yearly emissions. This does not include biogenic emissions from burning wood, in accordance with international standards (IPCC, 2016).

Community Garden (*Hort Comunitari*)

The community garden is maintained by a few families and grows local vegetables, like in many other Spanish TTs. It was built a bit outside of the town, near the local river for facilitation of watering. The community garden here also grows all of "the typical" seasonal things.

Based on the quantity of local food it produces, the garden saves **310 kg CO_2-eq/year**. This assumes that all of the locally grown vegetables replace a long-distance distribution of food; however, the interview signaled that some of the local vegetables produced go to waste, because there is more

yield than demand. Therefore, the result comes out a bit higher than the reality, but still equates to only **6%** of a person's yearly emissions.

Local Chicken Coops (no official name)

Eight families house local chicken coops, from which they harvest local eggs from organically raised chickens, rather from a faraway factory farm. Because no data on the average amount of eggs laid was available, it was assumed to be equivalent to the production levels at the similar project in Granada, meaning that **110 kg CO_2-eq/year** is saved through this project, **2%** of a Spaniard's average emissions.

Festival of Giving (*Fira del Donar)*

Every year, a free item exchange like that of Granollers takes place in Argelaguer. People bring items to give away, and in return, take anything that someone else has brought (at no cost). There was a lack of concrete information available about the exact parameters of the event and contents offered. This could be attributed, in part, to the fact that each time there is a new variety and count of items brought to the exchange, and no one is in charge of keeping official track of what is brought to give away or taken to give a second life. Therefore, using the same formula for estimation of the similar event in Granollers, it is assumed that the two have about the same content in terms of item type and quantity. The amount of tables (6) to place items on at both was also a match; therefore, the only known difference is the number of times it takes place per year. Since there is one annually at Argelaguer, versus the semi-annual event in Granollers, the results calculated for the Granollers initiative were simply divided in half to estimate that of Argelaguer – equaling **1210 kg CO_2-eq/year**, or **24%** of an average person's yearly emissions.

Car Sharing (*Compartir Cotxe*)

The ridesharing system in Argelaguer follows the same idea as that of Santa Coloma (and most other car sharing initiatives). Here, potential shared rides are offered over a group chat with 17 members. The same problem as with Santa Coloma's avoided emissions also presented itself here; if someone takes up on the ride, they are most likely to respond by messaging the driver personally, rather than over the group chat. Therefore, assumptions had to be made about the percentage of rides accepted over the course of a year. Assuming that an average of one pair of people share a car to and from work in Girona during the work week, and that one ride to and from Barcelona is shared every two weeks (through the TT's car sharing project), an estimated **3250 kg CO_2-eq/year** is saved via avoided car use, **64%** of a person's yearly emissions.

Natural Heat (no official name)

Two households in the town abstain from consuming any energy for heating from April to October, including to heat water. This is made possible by a sort of solar tub affixed to the house, whereby water for the house (comprised substantially of rainwater captured by the house's rain barrels) fills this oversized bucket, connected to the pipes in the house. The water absorbs all the sun's heat during the day, and the capacity is great enough (135 L) so that, by the evening, the homeowners can take full, hot showers without the consumption of any electricity or other emission-creating heat

generation source. The water also fulfills all needs for cleaning, etc., without more than the sun's natural heat. This is an inexpensive, low-tech way to take advantage of solar power if solar panels are not an option for financial, technological, or infrastructural reasons. The summed efforts of these two households alone avoid **340 kg CO_2-eq/year**, or **7%** of an average Spanish person's annual emissions. While this number taken at face value is low, it should be contextualized by the fact that only two households are participating. The potential, if expanded, of this initiative is great (addressed further in the Discussion).

Total

Through a combination of all the projects at Argelaguer en Transició, **5300 kg CO_2-eq/year** are avoided overall, also more than the Spanish per capita standard yearly emissions (**104%**).

4.5.2. Argelaguer: Excluded projects

In Argelaguer, they are working on a translation of *The Energy Descent Action Plan*, by Rob Hopkins, to Catalan (*Guía para o descenso enerxético*). The content of the original text may not be accessible or interesting for some people to read in something other than their native language; therefore, the translation would potentially decrease home and industrial energy consumption across Catalonia with this simple yet explanatory resource; however, its current impact at the time of calculations was zero, as the translation is incomplete. Additionally, there is an "electronic library," whereby an online source of downloadable PDFs about Transition, etc. has been made available. This encourages and supports the spread of information but is also unquantifiable.

Argelaguer has a seed bank, in an idea similar to Santa Coloma's seed exchange, through which anyone can access seeds of beets, onions, peppers, tomatoes, eggplants, and lettuce and take up to 50% of the available seeds to plant. This project contributes to the recovery, production, and exchange of seeds adapted to local conditions, promotes food sovereignty, and rejects GMOs – but was not able to be part of the calculations.

The Library of Things (*CosaTeca*) is a loan service for tools and other objects to avoid buying them new. In theory, it organizes conferences and workshops on different trades and construction and repair tools, while fostering mutual trust and promoting self-reliance. However, it is hardly used in practice, so it did not register in the calculations. The issue is the same as records with the ride sharing programs; the small-town environment eliminates the need to document use in an official capacity. Because there was no one place to go for the tools (with multiple families offering various tools for loan, registered in the Library of Things), it is easier instead to go to a neighbor and ask to borrow the item, versus going through a formal electronic process. However, it still deserves a place in the discussion for the potential it could have if fostered and promoted; the idea might also give other TTs inspiration for a free but helpful project to implement.

The Argelaguer Consumer Cooperative is like that of Granollers, but with less participants and some products coming from other countries (therefore, not all products are local, so the project has been

excluded – also for low use). Still, it should be mentioned, because all food and drinks are bought from organic producers in an effort to promote environmentally-friendly products.

4.6. Overall results

Based on the compiled impact of the five Transition Towns studied (Table 6), an estimation was made for regional and national potentials, if everyone were to join the Transition movement (Table 7). Totals may be slightly above or below the sums due to rounding.

TABLE 6: TT MEMBERS AND EMISSION AVOIDANCE EQUIVALENCIES

TT	Core members count	Estimated avoided kg CO_2-eq/year (current)	Equivalent to ___ of annual average per capita emissions in Spain (current)
Granada	23	250	5%
Santa Coloma	10	4200	83%
Cardedeu	10	10	0%
Granollers	14	6060	119%
Argelaguer	20	5300	104%
Total	**77**	**15800**	**311%**

TABLE 7: PROJECTED EMISSION AVOIDANCES, SCALED TO A LARGER POPULATION

Area	Population (millions)	Proportion of population that TTs represent	Projected avoided Mt CO_2-eq/year if whole region transitions	Equivalent to the emissions that ___ Spaniards cause per year (thousands)	Extrapolated potential reduction proportion of total area emissions
Catalonia (regional)	7.5	0.000718%	2.2	430	6%
Spain (national)	46.5	0.000165%	9.6	1900	4%

National and regional potentials were calculated and examined. Based on average emission levels, if everyone in Catalonia joined the Transition movement, expanding the Transition Towns from this region in the same state they are now, this would reduce the emissions level on a regional scale in

Catalonia by about 6%. If the same extrapolation was made on a national scale, the emissions avoided could lower Spain's total impact by 4%.

4.6.1. General remarks on results

In many respects, the social benefits offered by TTs are as important as the environmental ones. This is relevant because any movement must begin with a social base and garner support to gain swing. Then, the people that feel they have a community will want to participate in and support it, and will be more inclined to join in the environmental initiatives posed for the future. As is stated in Smith (2010), just creating the momentum of interest to start an Energy Descent Action Plan (EDAP) in a city is demanding, let alone agreeing on scale and key actors. For instance, Hopkins, the head of TT Totnes, suggested 10% of the population should have heard of Transition before launching an EDAP. Therefore, it is important that these projects are often informational and awareness-raising, even if they have no directly tangible effects to include in this study. Furthermore, the focus of Transition Towns is not on creating an immediate impact, but rather, as part of the four assumptions (Hopkins, 2008) states: on long-term resilience. With this objective in mind, educational initiatives are a key tool in accomplishing such a goal. As Hielscher, Seyfang, and Smith (2011) state, Transition initiatives bring together locals to make the community more economically self-sufficient and resilient, embedding new energy-related consumption practices directed towards anti-consumerism and anti-growth. They try to influence the social, infrastructural, and cultural context of actions, thereby changing contexts rather than minds (Sustainable Development Commission, 2011). In this way, creating programs, as the TTs studied in Spain do, that raise awareness and build well-rounded perspectives for a long-lasting, resilient change can help in working towards achieving the bigger picture goal – even if it means smaller emission reduction values in the short-term.

Each Transition Town studied has or will have a community garden, many of which are organic. This shows how the current trend in sustainability in Spain is this local, organic food; it is the easiest thing to start with, especially on a low budget. As the trends edge toward renewable energy, the impacts of these cities will be a lot more potent; Santa Coloma has already begun consideration. This could be due to the fact that their TT is connected to a university (Universitat Politècnica de Catalunya) in the nearby, bigger town Igualada. A direct connection to science and advancements in technology, innovation, and renewables helps put them ahead of other TTs in terms of planning and project outlook. In this way, this TT could be seen as a frontrunner – leading in ideas and implementations of projects considered progressive in Spain – so that other TTs will follow suit in years coming once information is better diffused and benefits more widely understood (although they do not have the greatest total emission reduction, despite the advantage). By seeing the effects of their projects quantified, they may realize that their objective impact on the environment is not as potent as they may have expected. These results are not to undermine their efforts, but to encourage thought outside of the traditional Spanish TT box and set their sights on bigger, more complicated and more expensive – but also dramatically more impactful – projects than the smaller undertaking at the present.

4.6.2. Sensitivity analyses

The first sensitivity analysis was conducted on the weight of Granada chicken coop eggs. It was assumed that they were medium-sized eggs, as there was no indication that they would have a different size than average. However, even this assumption led to a range of weights, 0.045 to 0.080 kg, per egg (Egg Info, n.d.). Therefore, the exact middle of this range was selected, 0.058 kg per egg. To test the importance of selecting the middle of this range, both ends of the "medium-sized egg" weight spectrum were multiplied over the course of a year. The result of this sensitivity analysis is shown in the first bar of Figure 7. The same analysis could have been done for Argelaguer's eggs, but the other input values did not vary much; therefore, it was deemed unnecessary to conduct, as the results of Granada could also be applicable to Argelaguer.

An assumption that affected all Transition Town calculations was the yield per m^2 of community gardens. Sources indicated that production levels could range from 1.20 to 19.53 kg per m^2 per year (Grewal & Grewal, 2012); however, the upper end of this range was for a hydroponic roof garden, known to produce vegetables at a rate much higher than the average, a system incomparable to the type of gardens visited at the Spanish TTs. Therefore, the highest production rate for a category plausibly similar to that which was seen during field work was 6.20 kg/m^2/year (ibid). A sensitivity analysis testing these ranges was conducted to assess the potential variability in the results, seen in the second row of Figure 7. Santa Coloma was the TT selected as an example to test the effect of the different extremes, although the test could have been applied to any of the gardens, since they used the production levels in the same way in the calculations. While the estimate for production per m^2 was deemed to be acceptable, the sensitivity analysis shows greater implications for potential in maximum garden space utilization, if the TTs were to adopt best practices for higher productivity.

The Free Exchange Markets (analyzed for Granollers, but also applicable to the results in Argelaguer by dividing the sensitivity results from both ends in half) were a source of many assumptions. Because there was little concrete information for exact calculations given, it is possible that the results could vary. While maintaining the basic assumptions about the electricity emission factor for the country and clothing being exchanged at the market, the kWh for lifetime energy use of the articles of clothing, types of clothing offered, and remaining lifetime of the items were manipulated to demonstrate the potential minimum and maximum of GHGs saved from the exchange market. The results of this sensitivity analysis are shown in the third row of Figure 7.

In Argelaguer, the results for the Natural Heat project depended in part on an assumption about yearly electricity consumption. The number chosen as the most likely value for this was 2749.65 kWh, according to Roemro-Jordán et al. (2014). However, according to the same study, values could range from 764.6-4776.12 kWh. The results of testing the minimum value are displayed in the fourth row of Figure 7. Because the two households participating in this program were already very environmentally-driven, it was assumed that they would not have previously been on the highest energy-consuming end of the spectrum, and therefore that an upper-end sensitivity analysis was not necessary.

Finally, the results for the sensitivity analysis of the car sharing programs in Argelaguer (assumed to have a similar spread in Santa Coloma) had the largest range of variability, as shown in the fifth bar of Figure 7. The test ended in the minimum extreme being zero emissions avoided (if no rides are

actually shared in practice). The maximum number of rides saved was calculated for if all 17 members of the group ride share chat carpooled to and from work in Girona together on weekdays, also allowing one roundtrip per weekend day for potential overtime shifts or leisure trips. This saved distance was added to the sum of kilometers saved from daily round trips to Barcelona, assuming that the maximum would be one pair of people per day on average wanting to go to Barcelona, either for business or pleasure. Since this project accounts for a large portion of both TTs' yearly emissions savings, it should be noted that the high sensitivity of this variable embeds some uncertainty into the system totals.

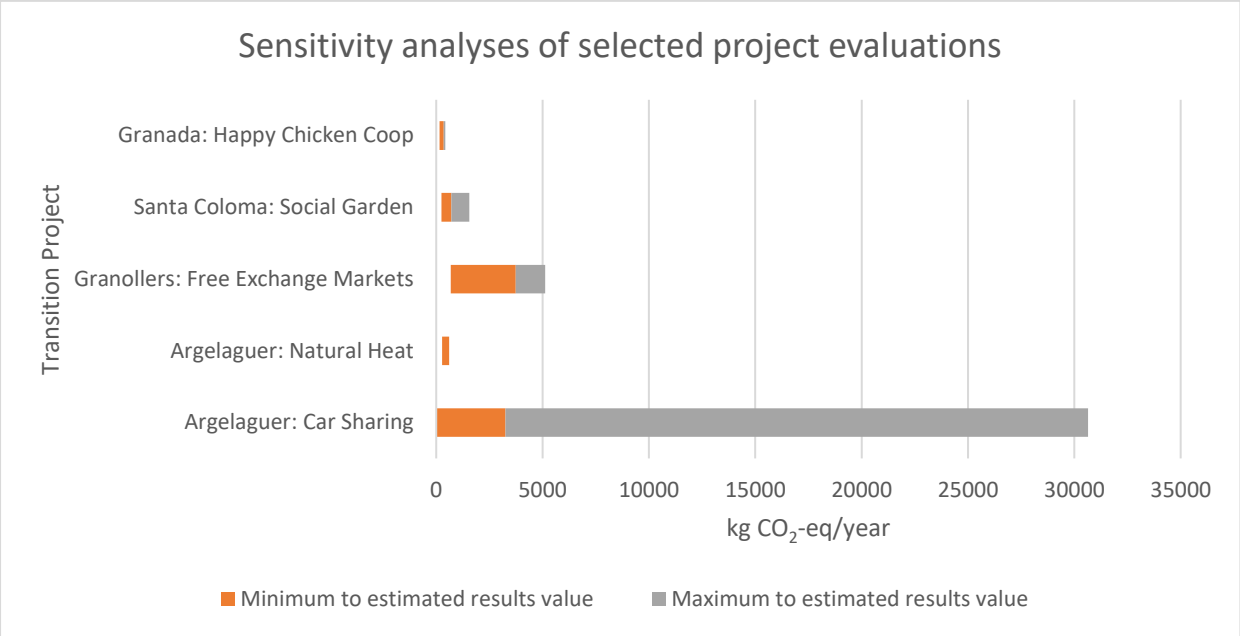

FIGURE 7: SENSITIVITY ANALYSES OF SELECTED PROJECT EVALUATIONS

It can be seen from these examples that there is uncertainty embedded in the system, yet it is not so profound as to undermine the results. Using the minimum and maximum values from the sensitivity analysis in place of the estimated values used in the results, an uncertainty analysis was made for the whole system, shown in Table 8 below.

TABLE 8: SYSTEM UNCERTAINTY ANALYSIS

Area	Avoided tonnes CO_2-eq/year	Projected avoided Mt CO_2-eq/year if whole country transitions	Equivalent to the emissions that ___ Spaniards cause per year (thousands)	Extrapolated potential reduction proportion of total Spanish emissions
TT totals (minimum)	9.9	5960	1170	3%
TT totals (maximum)	45.5	27500	5410	12%

While this uncertainty analysis does not account for every potential variation in all projects, it gives an idea of the variation in the system as a whole. The results indicated that 100% TT conversion in Spain would lead to emission savings equivalent to 4% of what is produced annually in the country. The uncertainty analysis shows that this figure could potentially range anywhere from 3% to 12% of national annual emissions. Therefore, taking this margin of error into account, it can be seen that, while not precise to the percentage, the results still can be taken as a strong representation of the Transition movement's potential impact.

Chapter 5: Conclusions

During this study, in addition to general information about a wide range of sustainable energy initiatives in Spain, five Transition Towns were analyzed closely to determine just how great the sustainable effects of this movement in Spain are, operationalized by a quantification of greenhouse gas emission reductions: both proven and potential. Individual programs were compared to each other, as well as the Transition Towns in their overall cumulative effect.

5.1. Answering the research question

The original research question was: How do the collective initiatives in Transition Towns in Spain affect local levels of greenhouse gas emissions, and what could the magnitude of their contribution be on a regional and national scale? It was broken down into three subquestions to more fully address the answers it sought. They are each answered separately in the following sections.

5.1.1. Changes implemented and supported

There were no infrastructural projects in terms of solar panels, wind turbines, or more efficient cooling systems or appliances. However, the concept could be extended to include the evaluation of energy demands to make it possible to estimate the renewable energy generation level necessary in Santa Coloma, the solar heating water basins in Argelaguer, and the aquaponics system in Granada (the former still an idea, and the latter two of which would be considered rudimentary infrastructure). Granada has also begun the process for installing composting bins, and Argelaguer purchased a wood oven (which is a basic start and not extremely impactful, but consequently is accessible to anyone for its simplicity and low cost – particularly if one is bought per TT and shared among participants). None of the preceding are highly emission-reducing in their current state; possibilities for improvement and expansion will be addressed in the section on potential, 5.1.3.

Transition Towns seem to generally target behavioral changes, rather than infrastructural. The biggest general behavioral change is a shift in preference for local products, especially food. Four of the five TTs studied have a community garden in effect, and the fifth has one in the works. There are local markets for selling artisan items and local saffron in Santa Coloma, and both Granada and Argelaguer have begun raising chickens to consume their local eggs instead of those from the market. Similarly, the Free Pickings project in Cardedeu promotes taking advantage of the local fruits and nuts, which are both free and local. These initiatives benefit all pillars of sustainability: the environment (assuming production impacts are equal, transportation is a large factor avoided), economics (bringing money to the local economy, rather than paying for corporate-run alternatives), and social (a way to gather locals and congregate with the community).

Building on this, a shift in eating and consumption overall is also encouraged by the TTs, for example: the group vegetarian meals in Granada (which are also very important socially). Consumer

Cooperatives in both Granollers and Argelaguer have become popular for procuring things from the "most local" possible destination.

Many of the behavioral changes are unmeasurable. Because Spain is still catching on to the "trend" of sustainability and understanding its importance, many projects are for educating and awareness-raising. They contribute to a long-term effect, but do not have a way to be incorporated into the calculations for avoiding GHGs.

The next most prevalent category of behavior change is a shift away from fossil-fueled transportation. Both Santa Coloma and Argelaguer offer ride sharing platforms, though this cannot necessarily be deemed a change brought forth by Transition initiatives. In Spain, the platform Blablacar is already popular and has the same general function. However, the local groups are still important and add further emissions savings otherwise not possible for lack of connection to small towns by the big ridesharing companies. As uncovered in the interviews, some of these TTs are very poorly, if at all, connected by public transportation. Therefore, after a certain required travel distance, the only option for arriving more sustainably is by sharing a car, so the effects were still important to capture in the equations.

The bike substitution programs in Granollers are a shift in behavior away from fossil-fueled transportation (in a country where biking is not the normal mode of transportation). Because they involve people all over town, the practice of biking for the TT may help them acquire the habit of biking for individual errands and social calls to which it is possible but not necessary to drive a car. It also may change the behavior of people with a more influential role, like library administrators or delivery service managers, who see that it is possible to have success, as well as lower costs, utilizing bikes instead of vans.

The initiatives also promote behavior change towards the values of repairing and reusing. Ongoing free exchange projects like the Festival of Giving in Argelaguer or the similar initiative in Granollers encourage behavior change, as it literally costs nothing for the people to exchange items and be more sustainable; this may develop into an individual habit countering the norm of throwaway culture. A similar mentality inspired a Repair Café to be set into motion in Granada, where people can bring their items to be fixed in an enjoyable, social setting, rather than throwing them away for lack of repair supplies, knowledge, or company.

The infrastructural and behavioral changes brought on by the TTs actually have substantial overlap. Some researchers argue that there is no such thing as only technical innovation, because all innovations must also include a social element in some way (Lash, 2003). Although hotly debated, the same line of thinking applies here. Everything that would be an infrastructural change must also be accompanied by a behavioral change; for example, composting bins implemented in Granada will do no good if people do not choose to use them. Similarly, the wood oven cooking would not be successful without a social aspect, or people willing to go out of their way to use a different oven.

5.1.2. Effect of the alterations, quantified in terms of GHG emission levels

In terms of collective program impact, Granollers en Transició showed the biggest overall GHG mitigation. This could be contributed to by the quality of the interview and their relatively high ability to reporting numbers. By attending one of their weekly meetings, it was possible to have seven people present at the interview, one always helping to fill in the blanks for what one of the others did not know.

Argelaguer has the second-largest overall impact of the five, suggesting that lots of hands, participation, and enthusiasm are involved. Although there are technically 20 members, there is primarily one man leading all the projects and making concerted efforts to avoid consumption and energy use. This can inspire individuals and start-up TTs in regard to their ability to create impact, and it implies that if everyone in the Transition group were to adopt such measures as the leader, the impact would be even greater. If this were to expand to the whole city, or region, or country, the magnified results show as even more impressive. In Argelaguer, the actions boiled down to conscientiousness about the environment and forethought in daily activities. For example, the leader does many simple things; in the winter, only one floor of the house is warmed, and all doors are closed, ensuring tight seals or filling in the gap below doors with a towel. The heat trapped is made through wood burning in a fireplace rather than with the standard gas or electric heater. During the summer, ventilation is achieved by opening doors and windows. The well-known Spanish heat is transformed into a positive tool with a simple, mildly innovative thought: the solar basin affixed to the house for emission-free water heating. These actions are simple and inexpensive, implying that anyone, even with a modest budget, also has the power to slash their individual GHG emissions to an extent close to one of the top GHG-reducing TTs in Spain.

The most surprising result was about the aquaponics system in Granada; it actually uses more energy than traditional agriculture and therefore emits more GHGs in total, even when considering the avoided impact of fertilizer use. It is for results like these that this research, and monitoring and evaluation overall, is very important. One caveat should be emphasized before continuing: these results are estimates and should not be taken as a gold standard. That said, it is actually possible that they are doing more harm than good (at least in terms of energy use and GHG emissions), while the users of this system may have implemented it for the sake of the environment. Still, it saves water and produces higher yields per meter squared (Okemwa, 2015), as well as avoids fertilizers and eliminates the need for nutrient-rich soil. Therefore, it simply depends on the goal of the project initiator whether this project should be considered a success or not.

5.1.3. The potential of Transition Towns in scaling up, based on the preceding quantifications

The biggest takeaway message is that results should not be taken at face value, but rather understood in light of their huge potential for, and inclination towards, progressive improvement. The results showed that if 100% of the Spanish population did what these five TTs have begun, it would reduce the national emissions by 4%, or 9.6 Mt CO_2-eq/year. This is more than what the entire country of Albania or Jamaica – two countries of different geographies and cultures – emit in

total per year (8.3 and 9.5 Mt CO_2 per year, respectively) (CAIT Climate Data Explorer, 2017). These numbers, as shown in Figure 8 below, refer to values excluding land use change and forestry, because guidelines from the United Nations Framework Convention on Climate Change (UNFCCC) for tracking the EU international headline target of 20% reduction of GHG emissions by 2020 should be "including indirect CO_2 emissions and excluding emissions or removals from land use, land use change and forestry (LULUCF)" (Eurostat, 2017). While these are admittedly small countries, the message prevails. The Transition movement in Spain is not impactful in terms of the EU's goals for 80-90% overall emission reduction, but on the same note, the reductions are also not negligible. By adapting a Spanish-wide TT movement, yearly carbon footprints with a magnitude of that from entire countries could be saved. A reflection on the possibility of this will be addressed in part of the discussion, section 6.2.

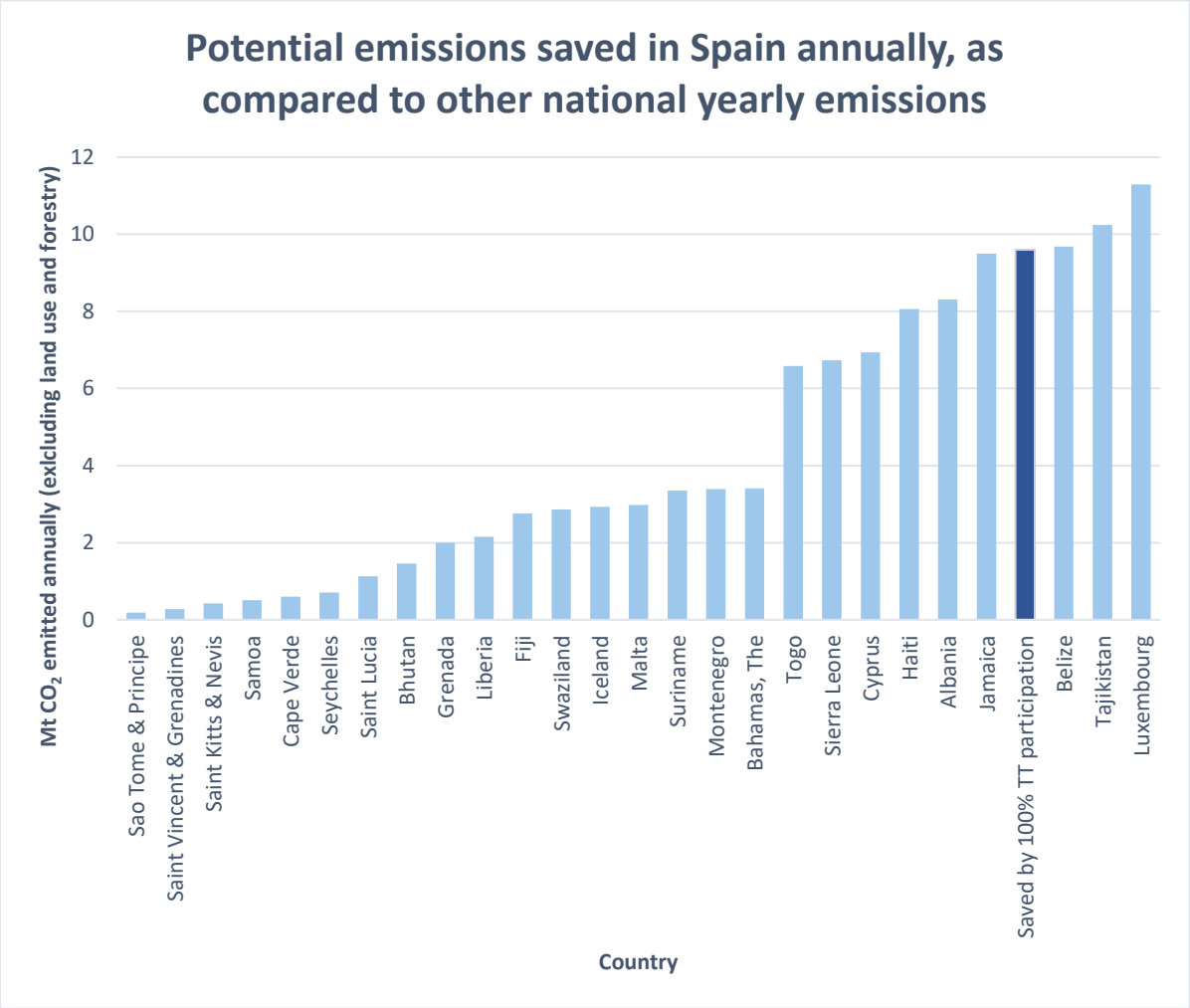

FIGURE 8: POTENTIAL EMISSIONS SAVED IN SPAIN ANNUALLY, AS COMPARED TO OTHER NATIONAL YEARLY EMISSIONS

As addressed earlier in the literature review section, the three mechanisms for diffusion include replication, scaling up, and translation to mainstream settings. Because the Spanish Transition

Towns have many projects for environmental education and raising awareness, many regular citizens of these cities who would otherwise probably not investigate the topic themselves become involved in debates on sustainability topics, documentary viewings, and other awareness-raising activities. Because the TTs embed themselves in the actual town and avoid the isolation that sometimes comes with non-mainstream thoughts and activities, they are able to support their own diffusion. Transition Towns in Spain are currently small, but through their education and resilience-building, they can lead to changes in many different ways. However, for this to be a successful large-scale endeavor, they need aid from community participation and governmental support.

As shown in Figure 2, Transition Towns have also been successful in diffusion by replication. The Transition Network in Spain is growing at about the same rate (in terms of number of established TTs) on the same time scale as the greater London area. Furthermore, it is growing at about the same rate as the Transition movement has in Italy, just about six years behind. Therefore, it is possible that in addressing potential for diffusion via replication, Italy's TT growth can be cautiously used to anticipate the speed of replication in Spain for the next six years.

Transition Towns have not traditionally been scaled up; while they may incrementally grow in number of members, this is not a goal of the TTs. In fact, the interviews reflected that too much scaling up could actually have the reverse intended effect by causing these groups that rely on strong social cohesion to become too commercial or impersonal. Project additions are possible and encouraged as a means to growth in some extent, but this mechanism for diffusion is the least suited to the Transition movement.

As shed light on by the previous sections, the results do not show the extent of the TT movement in Spain's reach, how much it has already developed, or how far it could be expected to grow. Numbers shown appear static, when they are actually quite dynamic. All interviews conducted, save Argelaguer, indicated that their groups are on the rise; for example, Granada en Transición traditionally met just a couple times a year, and now convene every month. They are on the upswing, with promising projects set to take off in November, e.g. the Repair Café (*Reciclería*) and another aquaponics system (although the results question the benefit of implementing another one of these systems, the initiative towards expansion is what is considered in the TT's trend towards growth). In Santa Coloma, the interview indicated that their saffron production also has been rising and is expected to grow with rapid vigor in the coming years. As mentioned previously, there is potential for renewable energy installations there (with all data complete, now just lacking funding). Turning the lens to Granollers, their Free Exchange Market sees consistently more items and people involved with each successive event. Additionally, they expect to implement a new extension of the existing bike path in the city. Their success then, in this sense, is symbolic and not adequately portrayed by a simplification to GHG emissions quantifications in the present moment. The results should instead be understood as a momentary placeholder for the GHG-reducing power these projects hold, with substantial expectations for growth in the next few years.

In a more macro scope, the general growth of the Spanish TT movement is also gaining steam. When Juan del Río's paper on the development of Transition Towns in Spain was published in 2009, there were nine documented TTs in the country. Now, in 2017, there are over 40 (Red de Transición, 2017). Their level of impact is impossible to say without an interview or on-site visit; however, in sheer numbers the TTs have grown five-fold in just eight years.

As examples of potential for growth, the Free Pickings project in Cardedeu may evolve into a town festival: for example, using fruit picked from the trees to make juice for everyone and setting up games like apple bobbing. The successful progression of this project could lead to the planting of more trees, or at least taking full advantage of all the fruit available. For the Granollers bike substitution projects, a stronger impact could be made if the deliveries are done more days a week (if there is a demand and capacity for this in the ongoing projects); it could also be expanded to other services as well, such as at-home grocery delivery.

Lastly, there is also potential for growth through the spreading of knowledge and ideas; this thesis can help facilitate the inspiration for adoption of projects. For example, Argelaguer's Natural Heat project could expand within the city or to other TTs. Other TTs may not have thought to do this before, because it is a bit unorthodox, but as all Spanish cities have this hot climate during the summertime, it would be possible for any to embrace this idea and implement it as their own. Similarly, Argelaguer's Library of Things officially counts as zero in the calculations here. However, if it was registered and used in a bigger city where the platform is necessary, it has great potential in consumption reduction and "getting more out of the object's life" by splitting the GHG burdens in a sharing economy.

From these comparisons and calculations, a future program initiator can peruse the data and make an informed decision about what projects to start with to most quickly and effectively reduce emissions if they do not know where to begin; a current coordinator could use it an inspiration to generate new ideas, make improvements, and start new programs to reach higher levels of emission reductions. To make the present findings more digestible for such an instigator, Table 9 displays a ranking of all projects studied, from highest GHG reduction potential to lowest:

TABLE 9: OVERALL PROJECT RANKING

Project	TT	Avoided kg CO_2-eq/year
Car sharing	Santa Coloma	3500
Car Sharing	Argelaguer	3250
Consumer Cooperative	Granollers	2610
Free Exchange Markets	Granollers	2420
Festival of Giving	Argelaguer	1210
Bike Delivery (packages)	Granollers	740
Local Markets	Santa Coloma	700
Social Garden	Santa Coloma	460
Natural Heat	Argelaguer	340
Community Garden	Argelaguer	310
Repair Café	Granada	210
Happy Chicken Coop	Granada	200
Organic Garden	Granollers	180
Bike Delivery (library)	Granollers	110
Chicken Coops	Argelaguer	110
Open Oven	Argelaguer	90
Kitchen in Transition	Granada	80
Community Garden	Granada	30
Free Pickings	Cardedeu	5
Community Garden	Cardedeu	5
Aquaponics System	Granada	-60

It can be seen from the top-ranking projects, such as car sharing programs and free exchange markets, that those with more potential also have more uncertainty.

This research also investigated possibilities for reducing emissions in a broader context and on a larger scale. The scaled results could alternatively be applied to use TTs as a benchmark for emission reductions in all of Spain. While it may not be realistic to expand to such a level currently, it can provide a tangible metric of achievement and help in defining Transition goals at the national level.

5.2. Criticisms

The role of TTs is to fill the gap in what the government is failing to do for the people; this seems like it would include renewable energy, although thus far it has not. If their goal is to transition to a "post-petroleum future," as goes the mantra of Transition Towns, they should also be driven by the desire to make strides to get there.

Out of the 21 considered projects, only one of them was pre-measured and quantified. There were no indicators or thresholds for success, which would be an important element in initiatives seeking to make a difference. If one person kept records, the TT could determine their degree of confidence about and the extent of the positive environmental impact their projects are making. Without this study, there would be no way to definitively defend whether they were making any difference. Since groups are small and resources are limited, it is very important that they are utilized in the most advantageous capacity if they want to make an impact.

Chapter 6: Discussion

In this chapter, the limitations of the study are described, and recommendations are made for Transition Towns and future research based on these as well as the findings from the results.

6.1. Limitations

While the goal was to learn what the impacts of sustainable energy initiatives within Transition Towns are, the complications of evaluating all and attempting to scale to a national level led to some uncertainty in the results.

First and foremost, the analysis was based on limited data. The calculations relied on estimates from a Transition member's best recollection, rather than measurements, for evaluating the GHG emissions saved. Therefore, assumptions had to be made using the partial pieces of the puzzle that were offered online or during the interviews. Sensitivity analyses were conducted if the researcher's assumption could sway results or might cause a potentially inaccurate representation of project impact.

For example, a significant percentage of contribution to emission reductions came from an educated guess about the continuation of rides being shared in programs such as that in Santa Coloma and Argelaguer. No written confirmation was available about current ride offer acceptances, as the program "devolved" from something organized, structured, and digital (at least in the case of Santa Coloma) organically into a much more casual system of "publishing" rides simply by chatting with friends coinciding in the street because of a small town size. There is not much work in either town, but lots in the nearest major city, i.e. Igualada, Tarragona, Barcelona, or Girona, so work commutes must coincide. Once one finds a ride partner, however, they can commute regularly in the same ride share arrangement, without posting necessary. Therefore, a large portion of the results rely on assumptions made about the frequency, distance, and continuation of such programs without formal records. An additional limitation: even if perfect data was collected about the frequency and distance of trips, a ride shared does not necessarily mean a ride avoided. People may take up on a ride to Barcelona if it is offered because it sounds nice for the weekend, but did not have to go otherwise.

Assumptions were also made by the researcher regarding the GHGs avoided from the Free Exchange Markets at Granollers and Argelaguer, for lack of better data available. Therefore, these results should be taken bearing this in mind; numbers are representative and give an idea of the effects of TTs, but should not be taken as exact. The Natural Heat project assumed the heat avoided would be from electricity, because it proved difficult to find records of how much gas is used in heating, although it is the preferred option for residential heat generation in Spain. This does not make the findings wrong, because some people do use electricity; however, the assumption could lead to a different estimation of avoided negative impact. When using rules of thumb regarding emission factors in these mathematical calculations, it is possible to estimate within a reasonable range of accuracy to make inferences and conclusions, but it should be noted that the numbers cannot be

interpreted to be as accurate as would be ideal. This includes the number of community members involved in the TT; a number of people was always given, but there were some people in the "gray" area, involved in some projects but not counting as an official part of the TT, or vice versa.

The intentions going into the study were also to compare similar programs to find best practices within the TTs, and then use one as a model for the others. However, because none kept strict records on things, for example in community gardens, such as water used, energy for irrigating or not, how much pesticide was used or not, or exact yields of the crops, assumptions had to be made about the average yield output per year. Since all stated that they grow "the typical," and none made statements about why their garden would be out of the ordinary, the same estimate for output levels, per m^2, was used for each. On the same note, all gardens were assumed to use zero energy for watering. This is because most of the gardens visited were hand-watered. However, there were some for which neither visits nor specifics were available, like in Granada and Santa Coloma, so the assumption is not with high certainty. Additionally, Argelaguer was seen to use a pump, which does consume energy; the GHG savings results in this town would then be an overestimate.

Because of this assumption, the only way they differ mathematically is based on garden size, so the results would imply that the only way to save more emissions would be to increase the garden size. While this would be a valid way to save more emissions, it is certainly not the only one. However, because the other variables were forced to be excluded for lack of specific measurements, inter-TT program comparisons to assess more effective program executions were not possible. In estimating community garden yields, there was one probable value selected from a range of possible yields ($kg/year/m^2$). Since it appeared in every TT and was sometimes one of few total projects, it did make a difference what value was chosen to input into the equation. It is possible that they are saving more GHGs if they are closer to the upper limit than assumed (the lower end of the sensitivity test was nearly the same as value given, so not as crucial for calculation).

Additionally, none of these equations factored in the possible role of a rebound effect; it was too difficult to assess its magnitude given the time and information constraints, so only the gross emissions savings from a project were calculated.

The entire life cycle of projects was not evaluated for the most part; primarily, only what happens during the use phase was assessed. For example, the manufacturing of the solar basin used must create a small portion of emissions, mitigating to some extent what it saves. Furthermore, because there was no data to indicate otherwise, projects like the local goods market were assumed to use the same material and energy input as their commercial counterparts, although this may be variable in reality. The exclusion of other phases does not undermine the validity of the calculations, but does create a potential to overestimate GHG emissions saved.

When making claims about Spain's emission reduction potential overall, an extremely small sample size was multiplied on a large scale. Therefore, any flaw in estimates given in interviews or any inaccuracy in assumptions made will be grossly exaggerated on a national scale. While the numbers can be taken as reasonably representative of potential national impact, there is about a 10% range of variability in the calculations. Additionally, based on those TTs who confirmed requests for interviews, there is not a sampling of TTs from every different region in Spain, which would make data better representative, since there are varying subclimates and subcultures within Spain.

Also, extrapolation for 100% Spanish participation in the TT movement is possibly an overestimate. Because the TTs interviewed host projects that also involve people from outside the movement like in car sharing, estimations made in the hypothetical equation that all Spanish people embraced the TT movement would leave no extra people on the periphery to be able to bring in for augmented participation. Therefore, in reality the results would be less, unless expanded to involve people from Portugal, France, or Andorra to compensate. Furthermore, in the hypothetical scenario of 100% Spanish participation, many aspects would not be possible in reality (e.g. chicken coops would probably not be found in urban settings). However, those areas with projects not possible to adopt in other environments could develop a new project that more rural and suburban areas would have trouble implementing. These factors should be noted when understanding the results for the extrapolation on a regional and national scale.

As previously discussed, many things do not appear in the calculations but are relevant nevertheless. In a benefit not included, emissions of particulate matter is avoided through bike delivery in Granollers, otherwise released by the stalled truck when delivering packages. Also, the results from Granada's Kitchen in Transition do not address any of the additional benefits substituting vegetarian meals, such as the water saved in the process for producing the same amount of food. Furthermore, there is no way to gauge the external effects of awareness-raising initiatives, since there is no way to follow all attendees to see how their behavior or mentalities changed. Even if they were to be surveyed, they may not be cognizant of the slow, small changes in their perspectives, and might not think to attribute their new, environmentally-conscious behaviors to the Transition projects.

This study originally selected Transition Towns as the subject for in-depth analysis for, among other reasons, their power to encourage sustainability through an amalgam of programs, rather than just one project in isolation. Ironically, its advantage for the environment means a shortcoming for its calculations. All of the projects put together have a collaborative Gestalt effect, in that "the whole is greater than the sum of its parts." Unfortunately, however, only the parts can be evaluated, so its whole value cannot be seen; TTs encourage people to take on more projects, act more sustainably at home in small ways, use less energy, and generally be more conscientious of the environment, especially by surrounding people with others who value these ideals and practices. Therefore, some aspects of the positive impacts must be missing. Yet, one can see this in a positive light by understanding that the more the TT movement grows in Spain (and elsewhere), the more people will be enveloped in this mentality, and the more positive effects will result: unmeasured, yet not unimportant.

6.2. Recommendations

6.2.1. For Transition Towns

This section contains recommendations for how to capitalize on the described potential of TTs. First, better national coordination and communication would facilitate higher impact and program expansion. The great ideas which may be unique to one and applicable for others should be spread;

otherwise there is much untapped potential for national growth not being capitalized on, e.g. Bike Package Delivery in Granollers, Natural Heat in Argelaguer.

Along the same vein, contact between the national Spanish and national English Transition coordinators could be effective. In this study, as Totnes is being used as the benchmark for furthest development of Transition Towns, international communication could continue the spread of successful projects and best practices. There are many volunteers involved in TT Totnes, so perhaps they could also visit the Spanish TTs with the most ambition to develop, to spread enthusiasm and garner more support from outside the inner TT circle in each town (since the meetings with highest attendance and biggest influence were often when a guest speaker came to town, e.g. the formation of Cardedeu en Transició inspired by Transició Vilanova's local lecture, Santa Coloma's first meeting attracting 150 attendees, and a successful meeting when Juan del Río – the Spanish TT coordinator – guest lectured in Granada).

Beyond the projects listed that will naturally grow, it is also possible to create even more growth with further initiative. Since community gardens are common across all TTs studied, this could be the first place to expand; it seems logical to make them as effective as possible. While high production is not the goal of some TTs now, if new ones form and value this, they can build the new garden in the most agronomic and high-yield way; those in place could also always improve their efficiency based on the recommendations here, should they decide that GHG reduction is their primary goal in having these gardens. When conducting a sensitivity analysis before realizing the structural cap on the input value, urban gardens were found to be capable of producing ten times what they are now, with specific practices (Grewal & Grewal, 2013).

While the energy required for the aquaponics system produced a negative value for emissions saved, the benefits beyond this are many. They need no soil and little space; therefore, it makes it possible to grow fish and crops even in the most urbanized areas. Fruits, vegetables, and fish can be produced locally and organically by eliminating the need for synthetic fertilizers and reducing toxic materials normally produced for farming. This has great implications world-wide for areas with poor soil fertility, and in areas with chronic protein deficiency; normal urban gardens can only grow vegetables and fruits, but this system also sustainably produces lean meat high in protein. To improve on the project's potential in Granada (and any other TT to implement it in), a best practice opportunity would be to utilize the minimum amount of water circulation, recommended by Bernstein & Lennard (2017): alternate 15 minutes of the pump on with 45 minutes off. By doing so, they could save up to 75% of the energy used for the system (although this would not suffice to compensate for its negative value).

In potentially expanding modeled off Totnes, their TT is listed on WWOOF (Willing Workers on Organic Farms), a platform for linking volunteers with organic farmers to promote cultural and educational experiences based on trust and non-monetary exchange to help build a sustainable, global community (WWOOF, 2017). This encourages international visitors and therefore the diffusion of the TT movement in Spain and outside, while enlisting the free help from others for more manpower in projects that require lots of hands.

Connections to universities could be a key factor for success. Those in the Barcelona area could connect with Universitat Autònoma de Barcelona, as Santa Coloma did with Universitat Politècnica

de Catalunya. They could recruit Master's or PhD students in the energy field to determine the energy demand in the TT and prepare everything for installing solar energy generation infrastructure, for example. The next call is then for the government, Spanish or EU, to offer grants for such large-scale and high-budget projects. Transition Town Totnes (2015)'s financial report could be used as a basis for funds application and budget allotment to facilitate the funds application process.

Furthermore, the social success directly correlates with the environmental success. All projects with a social aspect have been popular (e.g. Open Oven, community gardens, car sharing, Kitchen in Transition, exchange markets), while those projects attempting to move forward without a social element have much lower popularity (e.g. Natural Heat). This indicates that if future TTs want to take on a project in Spain, incorporating a social element will bolster their factor for success. As written on the official Red de Transición website, "*Sin diversión, no hay transición!*" (There can be no Transition, without enjoying the process.)

6.2.2. For future research

With Spain as a part of the European Union, it should be noted that within the EU-28, the sector exponentially most responsible for emissions is energy (versus agriculture, industry, and waste) (World Resources Institute, 2015). This has two implications relevant to this research:

1. It acts as support for the continuing argument that more should be done by TTs in terms of renewable energy. This could be as small of an action as buying a few solar panels or ovens, potentially even used ones; this would support the idea of reusing instead of buying new, while also making them cheaper and more accessible to small TTs. Because most of the TTs studied here are small towns, they would not need a whole solar park, with just some panels sufficing, while still having the potential to create a huge difference (as detailed in the answer of the first research subquestion regarding renewable energy installations). If policies and funding are obstacles, TTs can take smaller yet effective actions, like capitalizing on rudimentary solar power, as in the case of Argelaguer.

2. ENERGISE is a critical project for the EU, in terms of EU emission categories. Its findings from household energy consumption Living Labs would be a good place to start, and its research would have a great potential for impact in reducing overall emission levels.

This study, if nothing else, can be used as a "before" measurement for monitoring and comparing progress of TTs after a few years of development. Having this benchmark as a starting point is valuable for future studies monitoring progress over time and will give a better way to extrapolate TT potential, based on pace of self-growth.

A future researcher could study more in-depth TTs where awareness-raising projects are important in their initiative, potentially in a longitudinal study. As previously noted, promoting education or understanding without physical outputs that prove an avoidance of GHGs amounted to zero in the results. To further fill out this research, someone could attempt to study the behavior changes linked to these projects, whose effects would be seen indirectly. Since this study is the first of its kind two-

fold: the first study of TTs in Spain, and the first study worldwide (to this researcher's knowledge) attempting to quantify in any capacity the effect of TTs, further studies can bolster it in ways that were not possible in this one, for time or data constraints. Additionally, perhaps the interviews about quantifications will have spurred the idea in the TTs visited to begin to make measurements and pave an easier road for future researchers.

Any future study should check the assumptions made in this one. The strongest projects studied, in terms of GHG emission avoidances, are the car sharing programs. It is important to highlight that the results for these programs specifically are based highly on assumptions; therefore, the systems in which they are embedded are uncertain (yet not so much so to undermine the results put forth). For future research to improve upon the exactness and robustness of these results, those studies should focus on garnering clear answers. For example, the participants in ride share programs should be individually contacted to determine a much more confident estimate of how many rides are shared and for what distance. Future researchers with more time available should physically go to the TTs during harvest time and measure the unknown variables for the garden equations themselves. They should try to arrange interviews at one of the TT's regular meetings, so that more people are in attendance. In this way, fuller answers can come from the interview (not possible in the current study, for the need of all interviews to fit within two weeks).

For the Transition Town data to be able to translate into Spanish data, a number of factors would need to be checked. For example, what is economically feasible on a local scale may not be possible on a national one. To make an assessment, a techno-economic analysis could be conducted, or from a societal point of view, a cost-benefit analysis (CBA). While there is much to learn from studying TTs, neither of these analyses fit within the timeframe and should be conducted in another piece of research to determine if the results found here could ever be possible to achieve, given social elements, budgetary guidelines, and financial constraints.

While there is much to be improved upon in this study, it is the first of its kind. Although many assumptions had to be made, the results put forth by this study and the potential evaluated provide novel data; it is now up to future researchers to expand upon it.

Acknowledgements

Many people's efforts and support made the completion of this Master's thesis possible. First, I would like to thank my direct supervisors, Dr. Udo Pesch and Dr. Kornelis Blok, for their careful consideration of my paper and guidance since the beginning, from the project conception to all of the helpful resources and critiques along the course of the work. I would also like to thank Julia Backhaus for her clear, comprehensive feedback and positive reinforcement throughout the project; additionally, Dr. Réne Kemp for recommending my graduate research internship placement at ENERGISE, through which I gained a well-rounded research experience and met inspiring scientists and academics. Furthermore, I would like to express my gratitude to the ENERGISE consortium, particularly the International Centre for Integrated assessment and Sustainable development at Maastricht University, for extending the research opportunity and financial aid to help cover the cost of on-site interviews in Spain, without which the field trip would not have been possible (photos from which are found in Appendix E). I extend the highest gratitude to the MIND program and all of my MIND family, without whom I would be lost and probably still somewhere in the United States. Finally, I would like to thank my Gladiator, Tae Bo, and Yoga instructors for their amazing workouts that kept me sane throughout the highs and lows of this semester. Without these people and organizations, this completed thesis research project never could have become a reality.

List of Appendices

For further information and documentation of background work, kindly find the list of appendices, in order of appearance in the report:

Appendix A: “Spain Sustainable Energy Initiatives Grid” Excel file

Appendix B: “Spanish TT Contact Info” Excel file

Appendix C: “In-depth Methodology Explanation” Word file

Appendix D: “GHG Calculations” Excel file

Appendix E: “Spanish TT Photos” PDF file

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