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Facilitating Collective Action for an Integrated Community Energy System

INTERDISCIPLINARY PROJECT GROUP | MSC INDUSTRIAL ECOLOGY LEIDEN UNIVERSITY | DELFT UNIVERSITY OF TECHNOLOGY

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ABSTRACT

Integrated Community Energy Systems (ICESs) focus on joint use of distributed energy resources (DER) from a bottom up perspective. There is no single typology of ICES applicable to all situations, as they are tailored to the respective community needs for maximising energy performance.

This report explores whether the existing framework by Elinor Ostrom on Socio Ecological Systems (SES) is applicable to an ICES as a socio-technological system (STS). The main query we wanted to solve was: *To what extent are the variables from the SES framework applicable to an ICES and how can these variables together with empirical insights from a Dutch ICES case be used to derive recommendations for the implementation of ICESs?* The initial hypothesis was that the SES framework is applicable to the implementation of ICESs considering changing technology instead of natural resources, and prosumers instead of consumers.

In order to answer the research question and prove the hypothesis performed an empirical and theoretical analysis on a chosen case study: Ramplaan. With the result, we created a modified SES framework adapted to the case, which then was used to create a facilitation method. This method aims to aid those interested in using the SES variables for an ICES, by dividing the use of the variables according to three phases: enabling context, design and implementation. A practical application of the facilitation method was embedded into an organisational plan for ICESs. Afterwards the influence of selected variables of the facilitation method were tested in an agent-based model (ABM).

As a result, we managed to develop a method that offers a stepwise approach towards the implementation of the Ramplaan case, and potentially other ICESs. Within the method, we propose several tools to enhance the method efficacy. These tools came from our industrial ecology background knowledge. The proposed method could be generalizable but special attention should be given to the design phase dealing with the decision making variables.

For further research we suggest two options. Firstly, a thorough analysis of many existing other Dutch ICESs to justify our modified framework and methods. This would validate our findings and give the method right of existence. Secondly the method could be tested for numerous emerging ICESs to not only validate its applicability, but to analyse its effects when used and draw conclusions of the key variables for success. Implementing both suggestions would take long time, but the results could contribute to what commons' researchers claim is still missing in literature, which is the measurement of contextual variables in different communities and contexts.

1 INTRODUCTION

1.1 BACKGROUND INFORMATION ON THE PROJECT TOPIC

System innovations carry a large part of the opportunities for the transition to a more efficient energy system. Crucial are not only the renewable technology developments, moreover the governance and changes in the social environment are factors that should be approached. These transitions can be described as fundamental changes in the ways societal functions are performed (Geels and Kemp 2000). Among the different types of socio-technical transitions of energy systems, the Integrated Community Energy System (ICES) has been pointed out as one option with major benefits for transitioning towards sustainability (Koirala, et al. 2016). ICESs have been considered the best option due to their high degree of integration and value generation: Their design can include all kinds of technology, including small scale energy systems. ICES are tailored to the respective community needs for maximizing energy performance while maintaining energy security and striving for independence. The community can be any size and usually aims at reducing energy costs and environmental burden. Criteria used to assess and describe ICES include locality, modularity, flexibility, intelligence, synergic behaviour, customer engagement and efficiency (Koirala, et al. 2016). One of the most important attributes of the system is the possibility for households or users to exchange energy locally at local prices. Thus, in each case, proper mechanisms must be designed in order to ensure efficiency and fairness for local price setting, and also for the sharing of investments and economic benefits. ICES in fact promote a local scale economy.

Planning an ICES usually begins with the exploitation of one energy technology (Koekoek 2016). The starting point is to assess current infrastructure and available resources within the community. The objective is to find both socially and technically innovative solutions that fit prosumers. These prosumers have great influence on the project outcome because the boundaries for an ICES to are set by the respective community according to specific needs (Koirala, et al. 2016). Thus, ICES are not regarded as static systems; they will change and adapt depending on actual needs. Their implementation and value will differ when considering urban, rural, developing and developed locations. Reviews on ICES initiatives show that success depends on variables such as the local environment in terms of applicable regulation, available resources and degree of cooperation between stakeholders. Strong engagement and a high degree of involvement by local communities are portrayed as very important. Likewise, adequate legislation and developed accelerate projects. Lastly, ICES are all about citizens taking responsibility and designing an improved energy system to serve local needs be it reduced energy bills or even alleviated energy poverty.

Developed countries have already started experimenting with ICES, while developing nations could benefit from them by leapfrogging to cleaner and more efficient ways of producing and using energy. One advantage of developing countries and especially rural areas is that they are not restricted by existing centralized infrastructure. For these communities, ICES holds opportunities to improve access to energy. In the urban domain, ICES can play a key role in transforming the way that energy is produced and consumed. Depending on the used generation technology, ICES can contribute to GHG mitigation efforts and potentially be integrated in Nationally Determined Contributions (NDCs) focusing on the energy sector. Waves of innovation are characterized by sociotechnical shifts, now occurring at faster speed. In fact, the next big wave is expected to be the "green" one (EIO 2013). Rapid technology developments as well as cost reductions in energy storage and increasingly efficient renewables will promote ICES adoption in the near future. Grids reaching their end of life time will also add to the momentum for faster change. Engagement of end-users is an on-going trend, and ICES promote democratized, self-governed, sustainable, and smart systems.

Technically, many models are already available for optimizing the size and mix of technologies to gain the most benefits in terms of energy and GHG emission reductions. Socially, there are important issues to address. Barriers for ICES implementation include the general preference for the known centralized systems, as well as the lack of natural and economic resources. Moreover, scarcity of space in the community as well as conflict with local interests poses barriers. As a socio-technical system (STS), the business case for ICESs is full of complexity. Willingness to pay varies across communities. Up-front costs are usually high and banks are risk averse for granting community loans. Citizens might not feel comfortable participating and fear possibilities for free-riding among the community. Furthermore, as owners of an energy system, communities must decide what to do with generated energy surpluses, how to manage collective purchasing and energy conservation, and more generally how to allocate costs and benefits while avoiding negative incentives and rebound effects. One major barrier is developing energy governance. The needs for trust, motivation, and continuity within a community are not something that can be solved with the available technology alone. These are the nodes at which social sciences are needed to tackle the issues related to the governance of ICESs.

Energy in the form of electricity, heating or cooling is a product taken for granted, but in reality is the result of consuming natural resources which are finite. This also applies to renewables which have a maximum viable consumption rate. From this point of view, the energy that a community is able to generate altogether is the finite resource they must share. Moreover, communities must preserve the system that allows the respective resource to exist. Just as fish stocks and forests, energy in ICESs is collectively harvested and governed in communities. With regard to natural resources, many communities manage these under governance systems that are unlike any other; they are tailor-suited. And so the social studies about governing commons might hold lessons for ICES implementation.

The Institutional Analysis Development (IAD) framework and the Socio Ecological Systems (SES) framework are both developed by Nobel Laurate Elinor Ostrom and colleagues. They propose a systematized way for analysing whether the users of a common pool resource will self-organize in order to maintain their resource alive and functioning for their continuous self-benefit (E. Ostrom 2009). Both frameworks have been widely tested regarding management of resources like pasture land, water, fisheries and forests. But in fact, McGinnis and Ostrom (2014) argue that social scientists are convinced that the SES framework is also applicable to systems that need answers on governance of human-constructed facilities, rather than for ecological systems. From this perspective, the SES framework could be of great value for artificially constructed technological systems such an ICES.

1.2 RESEARCH QUESTION

In this report, we explore whether the existing framework by Ostrom on SES is applicable to a STS. We aim at formulating a framework based on SES variables and tested with empirical evidence from a selected ICES in The Netherlands, The Ramplaan. Our research is guided by following question:

To what extent are the variables from the SES framework applicable to an ICES and how can these variables together with empirical insights from The Ramplaan case be used to derive recommendations for the implementation of ICESs?

This general research aim will be supported by several sub-questions:

1. How do the variables of the SES framework apply to the case of the Ramplaan Energy Cooperative?
    a. Which SES variables are relevant when assessing the STS of the Ramplaan ICES?
    b. Which SES variables are not relevant for an ICES?
    c. Which SES variables need to be adjusted to accommodate analysis of STS like an ICES?
2. How could the variables have helped the initiators of the Ramplaan Cooperative to improve their governance and promote membership?
3. Are there any constitutional rules that can be considered as essential to ensure a successful ICES implementation?

1.3 GOAL AND SCOPE OF THIS INTERDISCIPLINARY PROJECT GROUP

The goal of this project is to learn the theoretical background, and importance of common good frameworks. We focus on their applicability for governance of socio-technical systems and aim at deriving recommendations for improvement. In order to have a thorough analysis, we focus on one case study: The Ramplaan Energy Cooperative in Haarlem in The Netherlands.

To achieve the mentioned goal, the following strategies were listed as steps to follow.

- Select an ICES case in The Netherlands and describe it using the SES framework.
- Analyse the selected case according to the principles of the SES framework.
- Identify key variables, eliminate redundant variables, and derive an adapted framework for STS analyses.
- Define a set of general recommendations to facilitate ICESs in The Netherlands.
- Provide specific recommendations to advance the selected case study, the Ramplaan Cooperative.
- Build an Agent Based Model (ABM) to analyse the influence of selected variables in ICES development.

1.4 SCIENTIFIC RELEVANCE

Authors of the SES framework have acknowledged important differences between natural systems and technical systems in regard to how users conceive them. They claim that it can be hard to find distinctions between a socio ecological system and a socio technical system from a framework perspective (McGinnis y Ostrom, Social-ecological system framework: initial changes and continuing chalenges 2014). In this sense, this research will contribute to testing the SES as a diagnostic tool for understanding its applicability and usefulness to an ICES. We will do so according to one case study of an existing Dutch ICES. The selected case study was the Ramplaan Cooperative, a 400.000 kWh solar PV plant that generates electricity for 220 members of the local community of the Ramplaankwartier neighbourhood in Haarlem (RVO 2016). We hope that communication of the results will benefit not only those working in ICES implementation, but also social scientist working in improving the frameworks for studying complex social technical systems.

1.5 SOCIETAL RELEVANCE

The societal importance of this research is given due to the diverse benefits that ICES provides for energy supply. These benefits are more likely to be realized as ICES develop at a larger scale, which can only be done when an organizational basis (that can be replicated) is provided. Recommendations for the most effective organizational structures or elements for ICES governance are needed. Results from this research were translated into a method that helps to facilitate ICESs. Although this research is focused on one case, the modified framework and the developed method provide a new step towards more comprehensive development paths. The successful implementation of an ICES can then result in diverse societal benefits which eventually reach households, local communities and society in general. From a household point of view, more consumers will be aware of their energy consumption and the importance of the role they can place by increasing their contribution to the energy system. For local communities ICES makes possible a fairer cost allocation and lower energy prices (Koirala, et al. 2016). In general, broad implementation and understanding of ICES dynamics will lead to more efficient energy use and reduce GHG emissions (Avelino, et al. 2014). This in turn will help mitigate climate change, and is likely to foster better technology development.

1.6 HYPOTHESIS

The initial hypothesis was that the SES framework is applicable to the implementation of ICESs with substantial changes to have in consideration: technology instead of natural resources, and prosumers instead of consumers.

2 THEORETICAL BACKGROUND

The theoretical background is divided in two main parts. The first one deals with the theories and frameworks developed under the topic of the commons, thus, the governance of common pool resources. The second part gives an introduction to socio-technical systems, whereby special focus is given on the Dutch energy system.

2.1 COMMONS AND GOVERNANCE OF COMMON POOL RESOURCES

Commons has become a buzzword, an empty concept that includes anything not privately held. Associated to rural environments the word usually refers to shared grazing or agriculture lands. There are also the "global commons", those who no one can own or control, but which are fundamental for life, like the air we breathe. Both types of commons, the ones nobody can own like air and the physical ones such as land fundamentally differ. Models and theories that are valid for one type of common good may not fit another (De Moor 2011). However, historically, the commons have been characterized by institutionalization and self-governance (De Moor 2012). One must bear in mind that there is a difference between access to public goods and common resources. Two features distinguish a common: (1) it involves one or several common-pool resources over which there are no established private property rights, and (2) it involves actions on the part of the individuals who use it to maintain its productivity (Anderies y Janssen 2013).

Common resources can be provided either directly from nature or created and provided by humans. Many historians describe how the commons (in reference to land) disappeared by giving rise to private property. Contrarily, nowadays, the collective management of resources is gaining momentum. The idea of self-governance among consumers in a bottom up approach has been growing since the 1970s because both governments and markets have proved unable to govern resources sustainably (De Moor 2012).

Several frameworks focus in analysing the governance of institutionalized, shared resources. This section gives an overview on the available literature on the topic. Types of resources are briefly revised. After defining institutions, the two frameworks provided by Ostrom are reviewed: Institutional Analysis Development (IAD), and Socio Ecological Systems (SES).

2.1.1 COMMON POOL RESOURCES

Two criteria define a common-pool resource: excludability and subtractability. In general, four types of goods are identified (Anderies y Janssen 2013):

- Private goods are subtractable and excludable: when in use, someone else cannot use them.
- Club goods (also referred to as toll goods) are non-subtractable and excludable: the use by one person does not affect the use by others but access to it can be restricted.
- Common pool resources are subtractable and non-excludable: they can be used by all but are prone to reduced availability.
- Public goods are non-subtractable and non-excludable: they can be used by everybody, and use by some does not reduce the ability of others to use it.

De Moor (2012) emphasizes that to anticipate problems that come from common goods usage, one needs to describe the excludability and substractability of the good. To enable proper governance of a common good regulation, organization and institutionalization are required.

According to De Moor, institutionalisation combined with self-governance is very important when studying commons. She suggests that in order to change our view on the institutional world regarding the commons, we need not to focus on the type of resource we want to manage but on the core definition of what an institution for collective action is. She further mentions strong stakeholder participation and clear incentive structure for developing successful institutions (De Moor 2011). She further claims that most the historical information that can be found on the commons is purely descriptive, which is why new theoretical studies are needed. But that using historical evidence is essential in understanding long term behaviour on ecology, social and economic effects of resource use in our environment. She also points out that although historians have usually considered commoners as homogenous groups, they seldom are because differences in social-economic background obviously influence their cooperative behaviour (De Moor 2012).

2.1.2 INSTITUTIONS AND SOCIAL NORMS

Institutions can be associated with enduring regularity; they are about the constant way of acting of humans. In many cases the word institution is used as a synonym of an organization. We tend to call the Ministry of Environment as an institution. But in social sciences, and for the study of common pool resources institutions must be regarded as rules, norms and shared strategies, as they are defined by Crawford & Ostrom (1995). Elements conforming institutions evolve in time because they depend on human interaction and repetitive situations. Because they are about repetitive accepted situations, institutions can have several ways of being displayed: spoken, written and even tacitly understood. They refer constrains, permits, prescriptions, advises and outcomes. Institutions are the norms and rules society uses to organize its desired behaviour, to organize societal life.

As part of the institutions shaping society, social norms play an important role for self-governance. Social norms are informal norms as opposed to formal, codified ones such as legal rules. They are functional in regulating social life and there are two types of them: descriptive and injunctive norms. The injunctive ones reflect perceptions of what others approve or disapprove of, and motivate action because of the social rewards and punishments associated with engaging or not engaging in the behaviour. The descriptive norms reflect perceptions of whether other people actually engage in the normative behaviour themselves and motivate action by informing people about what is likely to be effective or adaptive behaviour in a particular context (Smith, Louis, et al., Congruent or conflicted? The impact of injunctive and descriptive norms on environmental intentions 2012).

2.1.3 ELINOR OSTROM´S THEORIES

2.1.3.1 INSTITUTIONAL ANALYSIS AND DEVELOPMENT (IAD) FRAMEWORK

Hardin´s theory is that a common is likely to get overgrazed if the costs or burdens of a shared research are spread over all users but the benefits are private (Hardin 1968). His belief is that this results in a misbalance between restoration of the resource and accelerated usage, which will eventually result in self-destruction. This is known as tragedy of the commons. Ostrom, however, proved that open access governance does not necessarily lead to overuse. Through the analysis of case studies on commons, she developed the so-called Institutional Analysis Development Framework (IAD). This framework comprises the following terminology (Anderies y Janssen 2013):

1. Action arenas are the social space where participants with diverse preferences interact, exchange goods and services, play a game, solve problems, etc. The term helps to distinguish the incentive, behaviour and roles of those using the commons by setting the preconditions.
2. Action situation refers to the positions, actions, outcomes, information and control that provide the structure which determines participant's interaction. It provides the institutional context with which the participants in an action arena are confronted. More specifically, the action situation focuses on the individuals in respect to the action arena.
3. The number of participants and positions in an action situation may vary, but there must be at least two participants in it. Participants need to be able to make choices about the actions they take.
4. Participants are assigned to a position and capable of making a choice between different possible actions. Positions do not refer to people, but rather to roles that participants can play in an action situation. Control changes over time depending on the position of power.

5. The collection of available actions represents the spectrum of possibilities by which participants can produce particular outcomes in that situation.
6. Information about the situation may vary, but all participants must have access to some common information about the situation. Otherwise the participants are not in the same situation.
7. Intended consequences or unintended consequences of decision are considered outcomes.
8. Action describes the selection of a setting or of a value on a control variable that a participant expects to affect the outcomes. The moment an action is selected is seen as a choice.
9. Strategy describes a complete specification of actions under consideration of all possible variations of the action situation.
10. Institutions are prescriptions that humans use to organize all forms of repetitive and structured interactions. These may be rules or norms.
11. The rules that affect positions play an important role in how communities can sustain their commons. There are three levels of rules that affect the actions taken and outcomes obtained: operational, collective-choice, and constitutional choice.

By analysing multiple case studies using the IAD, Ostrom provided eight design principles to sustain common pool resources (Anderies y Janssen 2013):

- Clearly defined boundaries
- Rules specifying costs and benefits ending in proportional equivalence: They specify the amount of resource products that a user is allocated in relation to local conditions and to rules requiring labour, materials, and/or monetary inputs.
- Collective choice arrangements
- Monitoring: Auditors actively monitor biophysical conditions and user behaviour and are at least partially accountable to the users and/or are the users themselves.
- Graduated sanctions
- Conflict resolution mechanisms: Users and their officials have rapid access to low-cost and local action situations to resolve conflicts among users or between users and officials.
- Minimal recognition of rights to organize: The rights of users to devise their own institutions are not challenged by external governmental authorities, and users have long-term tenure rights to the resource.
- Nested enterprises: Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

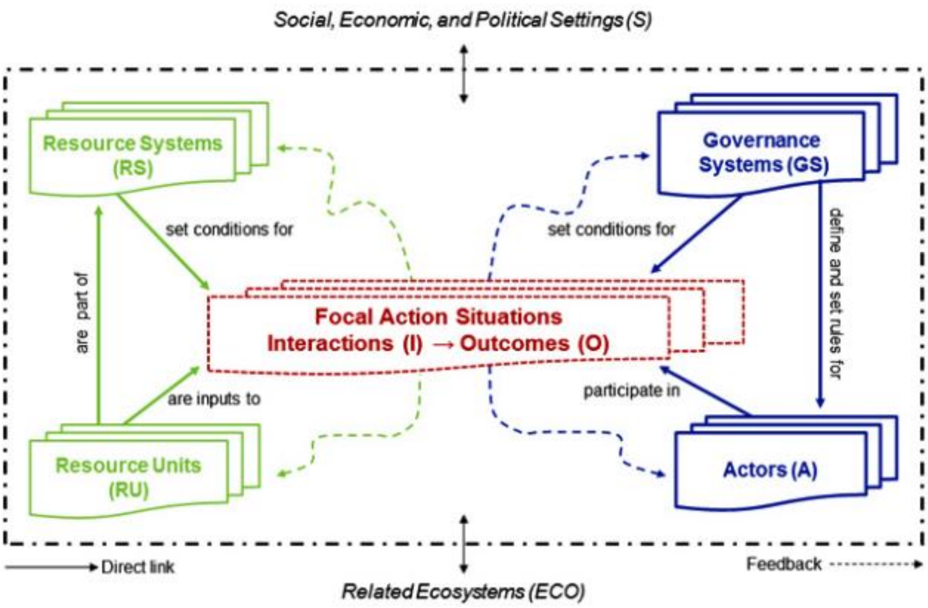
These principles are not blueprints for designing robust institutional arrangements; they are encountered regularities in a long list of real cases. They should be translated into questions to be used as a guideline to improve the institutional arrangement under study (Anderies y Janssen 2013).

2.1.3.2 SOCIO-ECOLOGICAL SYSTEMS (SES) FRAMEWORK

Since the publication of Hardin's theory on the tragedy of the commons and Ostrom's Institutional development framework about governing them, groups of users have invested considerable amounts of resources in the design and implementation of governance systems aimed at preventing destruction of complex socio-ecological systems (SES) (E. Ostrom, J. Burger and C. Field, et al. 1999, Ostrom, Dietz, et al. 2002, E. Ostrom 2009). All human-used resources are embedded in these socio-ecological systems. These systems are comprised of subsystems which can be viewed separately, but on a meta-level they affect each other. However, current policy focuses on each subsystem separately, thus, proving potentially ineffective since it fails to address the inter-relational effects (Pritchett and Woolcock 2004).

In 2009, Ostrom introduced the SES framework. Over the years, the original framework has been subjected to several incremental changes as a consequence of interactions between experts. Modifications have intended to make the framework applicable to a broader range of empirical settings, without making it too vague (McGinnes & Ostrom, 2014). A representation from 2014 of the framework is shown in figure 1, and consists of a set of subsystems: **resource system (RS)**, **resource units (RU)**, a **governance system** and **actors (A)**. These subsystems **interact** (I) with each other and produce **outcomes** (O) at the same level.

Figure 1: Revised Socio-ecological Systems Framework (McGinnes & Ostrom, 2009)



Each subsystem contains certain second level variables which can have both a positive or negative effect on the extent to which the community members engage themselves or contribute to self-organizing actions. The variables are shown in Table 1. The variables that are written in blue represent changes made to the variables with respect to the initial framework from 2009. For this report, we take this framework as a static given, and disregard previous versions of the model.

Table 1: Second tier variables of the SES framework (McGinnis en Ostrom 2014)

Social, economic, and political settings (S)	
S1 Economic development, S2 Demographic trends, S3 Political stability, S4 Other governance systems, S5 Markets, S6 Media organization, S7 Technology.	
Resource systems (RS)	**Governance system (GS)**
RS1 Sector (e.g., water, forest, pasture, fish)	GS1 Government organizations
RS2 Clarity of system boundaries	GS2 Non-government organizations
RS3 Size of resource system	GS3 Network structure
RS4 Human-constructed facilities	GS4 Property-rights systems
RS5 Productivity of system	GS5 Operational-choice rules
RS6 Equilibrium properties	GS6 Collective-choice rules
RS7 Predictability of system dynamics	GS7 Constitutional rules
RS8 Storage characteristics	GS8 Monitoring and sanctioning rules
RS9 Location	
Resource units (RU)	**Actors (A)**
RU1 Resource unit mobility	U1 Number of relevant actors

RU2 Growth or replacement rate RU3 Interaction among resource units RU4 Economic value RU5 Number of units RU6 Distinctive characteristics RU7 Spatial and temporal distribution	U2 Socioeconomic attributes U3 History or past experiences U4 Location U5 Leadership/entrepreneurship U6 Norms (trust-reciprocity)/ social capital U7 Knowledge of SES/ mental models U8 Importance of resource (dependence) U9 Technologies available
Action situations: Interactions (I) -> Outcomes (O)	
I1 Harvesting I2 Information sharing I3 Deliberation processes I4 Conflicts I5 Investment activities I6 Lobbying activities I7 Self-organizing activities I8 Networking activities I9 Monitoring activities I10 Evaluative activities	O1 Social performance measures (e.g. efficiency, equity, accountability, sustainability) O2 Ecological performance measures (e.g. overharvested, resilience, biodiversity, sustainability) O3 Externalities to other SESs
Related ecosystems (ECO)	
ECO1 Climate patterns, ECO2 Pollution patterns, ECO3 Flows into and out of focal SES	

While McGinnis and Ostrom (2014) emphasize that the framework is applicable to artificially constructed technological systems, they also note that important differences in interactions between users and such a system exist. Theory on sociotechnical systems will be introduced in a later part of this chapter. McGinnis and Ostrom introduce a way to use this framework suggesting three general steps: the first is to select a focal analysis level by identifying the most relevant types of interactions and outcomes related to the system. Secondly, the variables to be measured should be selected. The framework provides a complete base of variables for all cases combined, therefore not all are relevant. Thirdly, the framework must be used to communicate results across research communities.

The challenge concerning the study of SES as collectives might lie in capturing context. Poteete et al. (2010) stress the importance of micro-situational variables, the broader context and the relationship between them. They state that to study the governance of SES a multi-method approach seems necessary. The reason is that even in field experiments, such as role playing games, participants do not provide complete information about all situations of interests to theorists. Alternative formal modelling approaches, such as agent based modelling, have shown that conditional cooperation can be explained for a wide spectrum of conditions. Rational selfish behaviour is often conflicted by human emotion as experiments with theory of games have shown (Janssen, Bousquet and Ostrom, A multimethod approach to study the governance of social-ecological systems 2011). It appears that predicting outcomes from socio ecological systems has proved difficult. De Moor research shows that few studies are available on cross-country comparisons about interactions among commoners (De Moor

2012). She stresses the need to develop what she calls an *"institutional toolbox"* that can be applicable for describing interactions and outcomes under specific conditions and resources, no matter place or time (De Moor 2011).

In regard to Ostrom's SES framework, Poteete (2010) suggests that instead of measuring all possible variables, defining a multi-layered system of indicators that match the social-ecological system of interest is needed. In order to understand governance of the commons, she proposes: (1) measuring contextual variables more often and more systematically than usually done; (2) testing communities from different contexts: small, large, western, old fashioned, modern, etc.; and (3) building up a e-infrastructure to run comparisons (Janssen, Bousquet and Ostrom, A multimethod approach to study the governance of social-ecological systems 2011).

2.2 SOCIO-TECHNICAL SYSTEMS

The sociotechnical system theory is based on the interactions between humans and technology. Researchers have become more and more aware that technological innovations do not operate in isolation. Instead, their functioning is highly dependent on specific and complex ensembles of elements in which they are embedded. The interrelations between society and technology describe the effect of technological innovations more completely (Borrás and Edler, Introduction: on governance, systems and change 2014).

Other important work was delivered on further defining socio-technical systems. According to Geels (2014), several key factors are included. These are the production and use of technology, the linkages between elements (e.g. communication, transport) and the resources (knowledge, cultural meaning) that are necessary to fulfil societal functions. The sociotechnical system according to Geels (2014) is shown in Figure 2.

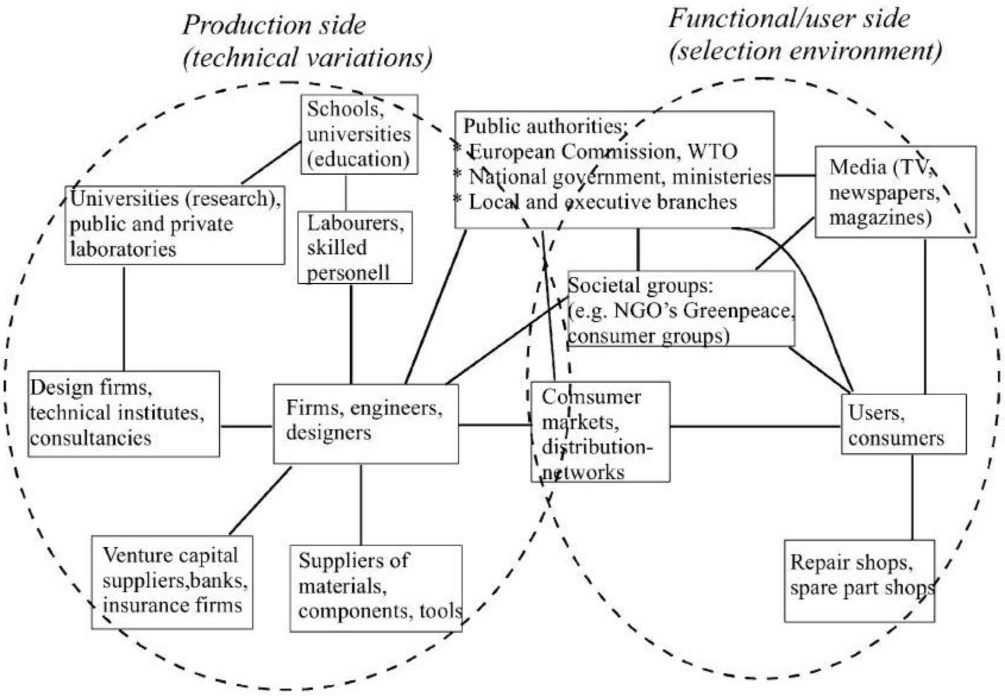


Figure 2: Resources and elements of socio-technical systems (Geels, 2004)

2.2.1 INSTITUTIONAL AND TECHNICAL STRUCTURE OF THE DUTCH ELECTRICITY SECTOR

ICESs are a decentralized approach to energy production and are as such in stark contrast to the current technological regime, the centralized power sector. Today, ICES in developed countries are usually connected to the centralized grid, which makes necessary that they integrate in the institutional and technological system of the technological regime. An overview of the centralized system is provided in the following section. Figure 3 illustrates physical and institutional layers of the sector in The Netherlands. The physical layer represents the technical system while the institutional layer shows organizational arrangements and actors in the sector. The physical layer is operated by the **transmission system operator** (TSO) and several **Distribution network managers/operators** (DSO). These are both companies that are publicly owned and strictly regulated to specific areas. They take care of the security of supply (balancing mechanisms), capacity management and grid connectivity.

Electricity producers are the electricity generating entities. These are mostly large power companies owning coal/gas fired and nuclear power plants, wind parks etc. Electricity producers are often referred to as "load serving entities". These companies sell their energy in several markets, the **power exchange** (also referred to as "spot market") and bilateral contracts (long-term contracts for fixed capacities during certain time periods) being the most important ones. The electricity producers sell to retail companies or directly to large consumers. The **retail companies** buy the electricity at the markets and sell to small consumers. The retail companies are separate companies focusing on contract management with customers and redistributing electricity which they buy on the market. Retail companies run the risk of volatile prices at spot markets. However, the fixed electricity tariffs paid by end customers compensate for fluctuating market prices.

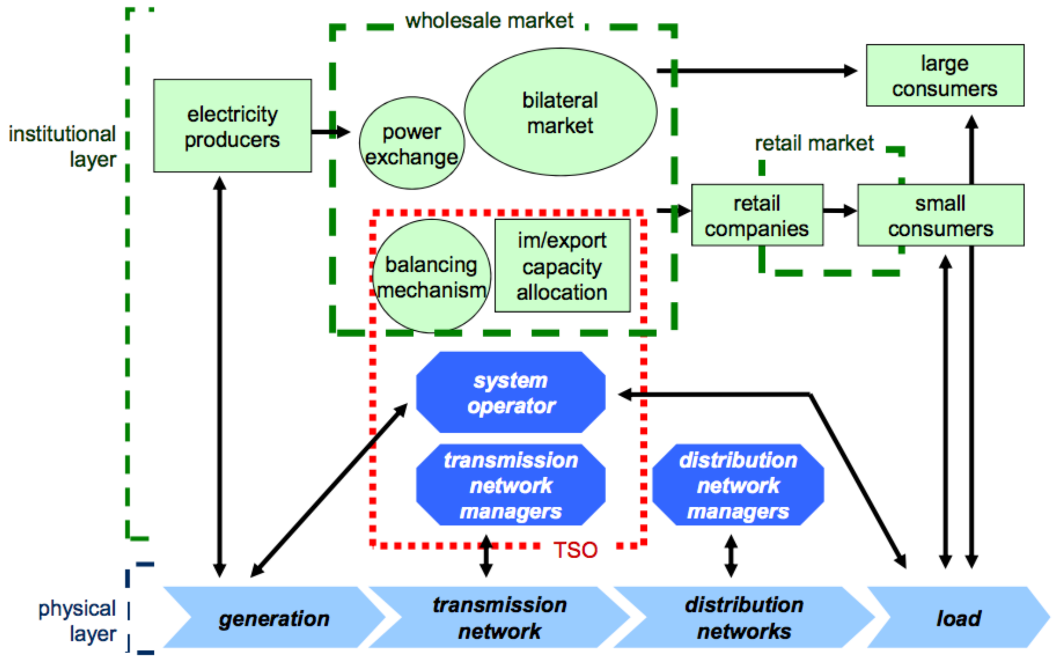


Figure 3: Conceptual Framework of the Dutch Electricity system (De Vries, Correlje and Knops 2010)

2.2.2 INTERACTION BETWEEN INSTITUTIONS AND TECHNOLOGY WITHIN INFRASTRUCTURES

Our research takes into account theory on technologies and institutions since the focus point of this report is on community energy systems and their governance. Integrated community energy systems can be regarded as a subsystem of the technological regime and its centralized infrastructure (Mendes, Ioakimidis and Ferrão, On the planning and analysis of Integrated Community Energy Systems: A review and survey of available tools 2011).Theory on infrastructure economics are therefore suitable to analyse ICES and are included in this section. According to Künneke (2016), infrastructure networks are socio-technical systems. He introduces a framework that emphasizes the interrelatedness between technology and institutions in infrastructures systems, which are as such well applicable to the electricity sector (R. Künneke 2008). According to the framework, a certain degree of coherence between technology and infrastructure is required for proper system functioning. There are three categories of performance criteria which describe system functioning: economic performance, public values and technical system integrity. Economic performance is on its turn categorized in three parts: static efficiency, dynamic efficiency, and system efficiency. Public values refer to the notion that infrastructures fulfil "*basic political and social functions that are fundamental for modern societies*" (Finger, Groenwegen and Kunneke 2005, 237). Two aspects of public value can be specified: Service of consumer interest (such as affordability, access, reliability) and system interest (such as security of supply, social protection). The last category is technical system integrity, which describes the ability of the infrastructure system to recover autonomously from distress. The framework (figure 4) attempts to connect the above-mentioned indicators of performance.

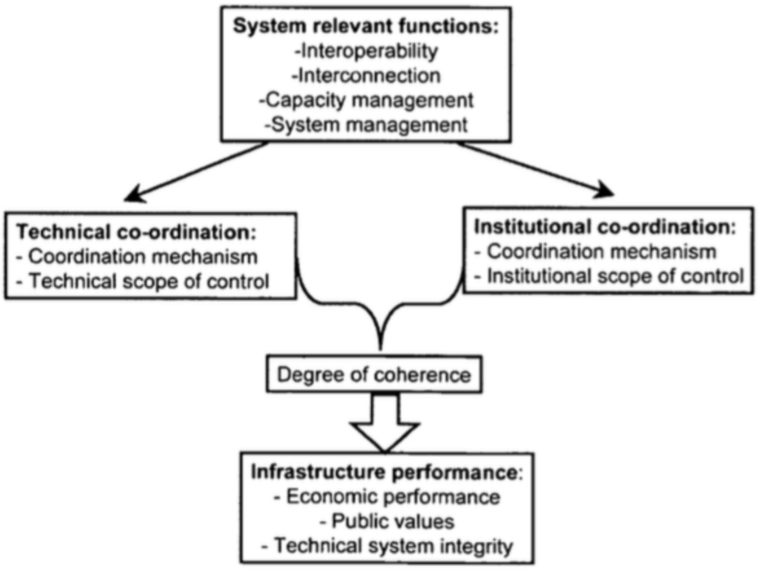


Figure 4: The relationship between technology, institutions and performance of infrastructures (R. Künneke 2008)

According to the framework of Finger et al. (2005), there are four "system relevant functions" of infrastructure systems (see figure 4). Interconnection describes the physical linkages of different networks performing similar tasks. Interoperability defines the conditions (technical and institutional) under which networks or elements of networks interoperate. This includes compatibility of different networks (e.g. cell phone networks of different countries) and the complementarity of nodes (e.g. cell phones with cell phone networks). Capacity management deals with the allocation of scarce capacity, whereas the system operator must ensure that available capacity is optimally allocated among system users. Lastly, system management deals with the system as a whole.

3 INTEGRATED COMMUNITY ENERGY SYSTEMS

This section provides an overview of the state of the art of ICES. The aim is to provide a clear background on all the aspects that compose and affect ICESs. This includes an explanation of institutional requirements of ICES, i.e. an analysis of prerequisites at community level and issues ICES face during their integration in the technological regime. A brief review of available ICES technologies is included. The chapter concludes with an overview of existing cases.

3.1 INTRODUCTION: ICES AS ALTERNATIVE APPROACH TO ENERGY GENERATION

The global electricity sector today faces multi-layered challenges in providing a growing world population with energy while meeting requirements to decarbonize the energy sector. The sector has undergone substantial changes in the past, ranging from liberalization of energy markets in the EU to a shift from fossil fuels to renewable energy. Under these changing market conditions, the centralized structure of the energy sector is no longer the sole government mechanism of systems, and innovative, decentralized systems are emerging.

One of these system types are Integrated energy community systems (ICES), which (P. B. Koirala, et al. 2016, 727) describe as *"[…] a network of prosumers having relatively similar energy sharing behaviour and interest, which make an effort to pursue a mutual goal and jointly compete in the energy market".* In practice, ICES are typically an arrangement of distributed energy resources (DER) which are operated at community level to generate power, to fulfil their own energy demand. There is neither single definition nor an established classification of ICES and existing systems differ in employed technology and size. An ICES may consist of a few households sharing a PV installation in a rural off-grid community in a developing country, or a group of several hundred households jointly investing in a sophisticated system. Regardless the level of sophistication and size, all ICESs entail the joint use of a common resource pool which requires investments, an effective governance mechanism, and integration with the technological regime.

3.2 RELATED RESEARCH ON ICES

There are many aspects related to community energy that have been explored in the past five years. Some of the main topics researched are drivers, barriers and issues of ICES and community energy in general. Allen (2012), Avelino (2014) and Koirala (2015) have done extensive research on these aspects. Koirala (2016) has also evaluated the value that ICES bring to local communities and trends shaping the development of ICES. Many analyses on technical aspects that ICES should contain have been published. For example, Mendes et al. (2011) analyse from a technical perspective the impact of ICES in current distribution networks.

From another perspective, there are several research papers that aim at explaining the social aspect of community energy. Frantzeskaki et al. (2013) reviewed examples of community energy projects and concluded that the latter represent a new form of energy governance and that more research is needed. Similarly, Tomc et al. (2015) analyse current governance in some case studies, and as a result, present social and technical aspects that should be considered to successfully implement community energy projects. According to Hufen et al. (2015), it is unrealistic to think that it is possible to replicate the procedure of successful energy cooperatives and to implement them on a large scale. This is due to the uniqueness of each case. Still, Hufen et al. (2015) agree that it is valuable to learn from the mechanisms.

Arentsen et al (2014) conclude that the joint impact of local energy initiatives on the whole energy system will be quite small. However, even if each case is different and might be hard to upscale, there could be ways to determine steps that should be considered to obtain successful ICESs.

3.3 PRACTICES IN ICES: EXISTING PROJECTS, SUPPORTING ORGANISATIONS AND NATIONAL POLICIES

There are several examples of ICES in several parts of the world, with different levels of integration. In the following section an overview of some case studies will be discussed. This provides a better understanding of the implementation of ICES in practice. The examples are divided as follows: existing ICES projects, supporting organisations and policies and regulations from diverse countries.

3.3.1 EXISTING PROJECTS REGARDING ICES IN SEVERAL COUNTRIES

Not all of these communities entirely fit the description of an ICES yet, but are on their way to become one. These projects are interesting to mention because of the way in which they are organised or how they funded their energy projects.

3.3.1.1 FELDHEIM (GERMANY)

The energy cooperative in Feldheim was realised in 2010 and is Germany's first town to rely on its own produced energy. Through community interaction and partnership with a private company, Energiequelle, the town started with wind turbines in 1995 and as time passed by, it has integrated more energy sources (Energiequelle 2016). Currently, the village incorporates several energy technologies: district energy from biogas, an electricity grid, solar energy and a battery that can store up to 10 MW. They also receive back-up energy from a woodchip boiler. Residents in Feldheim pay about 40% less for their energy bills than the average German household (Local Energy Scotland 2016).

3.3.1.2 DAWSON CREEK (CANADA)

Dawson Creek in Canada has a complete community energy plan. They focus on wind, solar and bioenergy (Council of Energy Ministers 2009). The city can be considered as an ICES because it integrates several initiatives, such as building auctions and retrofits, LED (light-emitting diode) traffic lights and a solar-ready bylaw. The strong involvement of the municipality allows for a constant update of plans and policies that support ICESs. The city encourages shared and renewable energy generation at a building scale because it aims to be carbon neutral and energy self-sufficient. Also, it has created policies to allow the use and regulation of small wind turbines on any type of land (Bernier 2011).

3.3.1.3 SAMSØ (DENMARK)

Samsø is an island of Denmark that has been working to become fully energy self-sufficient since 1997. In 2007, the island achieved this goal and it now plans to be fossil free by 2030 (State of Green 2014). Samsø has 21 windmills, 11 of which are land-based and 10 are offshore. The windmills are by 90% owned by locals, although some belong to the municipality (Visit Samsø 2015). The island's district heating is run by a local committee which is composed of and elected by consumers (Energy Academy 2011). Samsø produces more energy than it requires, so it sells its excess energy to the Danish electricity network.

3.3.1.4 REPOWERBALCOMBE (UNITED KINGDOM)

This project started in 2013 as a response to the exploration of fracking sites in the area (Bennet 2015). The community came together to ensure that their energy supply should come from environmentally friendly sources. REPOWERBalcombe was established as a co-operative social enterprise (REPOWERBalcombe 2015). It aims to generate all of Balcombe's electricity demand from community-owned renewable energy (REPOWERBalcombe 2015). The firm mainly focuses on solar energy and sells its surplus generation to the national grid. REPOWERBalcombe has mainly collected funds for its projects through crowdfunding initiatives and by selling shares to locals. Share prices start from GBP 250 and investors benefit from reduced energy prices and annual returns on their investment. Also, part of the company's profits go to its community benefit fund, which will be further investing in sustainable energy projects (REPOWERBalcombe 2015). In September 2015 it got permission to build a 4.8MW solar farm that would power the whole town. However, the project had to be paused due to less favourable policy changes, which among other things, reduced subsidies for solar-powered energy by 65% (Macalister 2015).

3.3.1.5 FINTRY (UNITED KINGDOM)

Fintry is a rural village in Scotland, and it is the first village in the UK that made a joint-venture with a wind farm developer. It has its own wind turbine and with the profits it has been able to provide free insulation for over 50% of the town's households. Its aim is to make Fintry carbon-neutral, and the community is investing in new projects such as the installation of micro-renewable heating systems (Local Energy Scotland 2016).

3.3.1.6 NEILSTON DEVELOPMENT TRUST (NDT) (UNITED KINGDOM)

NDT is a charity and social enterprise which aims to make a the town of Neilston sustainable in terms of energy generation. It was created in 2006, and is part of a joint venture that owns four wind turbines with a 10 MW capacity (NDT 2011). In order to get funds for the wind farm, NDT was able to negotiate with Carbon Free Developments Ltd (CFDL) a shared ownership that did not involve any investing commitments by CFDL until the project was approved. From this moment on, NDT owned 49.9% of the firm through the purchase of shares. This was quite successful, as it allowed NDT to be part of such a large project without the investment risks (Databuild Research & Solutions Ltd 2014).

3.3.2 SUPPORTING ORGANISATIONS

These organisations provide guidance and different kinds of support for communities that want to develop an ICES.

3.3.2.1 ENERGY4ALL (UNITED KINGDOM)

Provides assessment to communities to become energy cooperatives and to invest their money. Energy4all operates in two ways. One way is to offer communities a share on large developing projects. The other is to develop smaller projects that can be entirely owned by a community (Energy4all 2014).

3.3.2.2 COMMUNITY ENERGY SCOTLAND (UNITED KINGDOM)

It is an organisation that started as government based and developed into an economic aid-based organisation (Frantzeskaki, Avelino and Loorbach 2013). Their aim is to help develop community projects with loans, guidance and networking. They provide advice for achieving energy efficiency in community buildings. Also, they help communities with profitable energy projects to optimise their welfare by reinvesting their gains efficiently.

3.3.3 SUPPORT POLICIES FOR ICES

Several policies have been implemented in different countries that support the implementation of ICES. This section treats some examples from different countries.

3.3.3.1 DENMARK

Energy from wind turbines provides over 29% of Denmark's electricity generation capacity (DECC 2014). This is mainly due to the community involvement of the Danish, as most citizens and communities own the turbines. It is common that cooperatives partner with other actors, like municipalities. This is the case of the 40MW offshore Middelgrunden wind farm in Copenhagen, which is owned by Dong Energy (municipally owned utility company) and a cooperative (DECC 2014). According to Schreuer et al (2010), the success of the implementation of community energy projects in Demark is due to: strong local demand, incentives like feed-in tariff (FIT), tax advantages, capital support for projects and standard rules for grid-connection. A FIT is a policy mechanism where a fixed price is established for energy production in order to foster investment in renewable energy projects (Council of Energy Ministers 2009).

3.3.3.2 CANADA

Canada has developed specific strategies to develop ICES. In 2009 the Canadian Council of Energy Ministers developed a strategy, which was documented in “ICES a roadmap for action”, in which strategies are formulated that will help Canadian communities to integrate their energy systems. In terms of regulations, the province of Ontario sets an example. Since 2005, it has been implementing several policies that foster public transport and higher energy efficiency standards for buildings. Since 2009 it allows feed-in tariffs for renewable energy production (The Planning Partnership 2012).

3.3.3.3 UNITED KINGDOM

The UK had an attractive regulation framework for implementation of renewable energy, which led to expansion of community energy initiatives. By 2014 there were at least 5000 communities that had either started or finished an energy project since 2008 (Databuild Research & Solutions Ltd 2014). This information also showed that by 2014 there was 49 MW of capacity from community energy, which mainly came from wind generation. This was a result of the favourable feed-in tariffs (FITs) that were in place at the time. However, since 2016 community energy projects are expected to slow their growth, due to the reduction of over 50% in existing FITs (Macalister 2015).

3.4 GENERAL CONCEPTS: INSTITUTIONAL ASPECTS AND TECHNOLOGY IN AN ICES

This section provides an overview of the general concepts related to ICES, divided into three subsections. The first subsection treats energy governance at the community level, including several problems that can arise in these systems, such as freeriding and split incentives. The second section provides an overview on the institutional environment of the electricity sector. Lastly, the economic, social and environmental advantages are elaborated on.

3.4.1 ENERGY GOVERNANCE AT THE COMMUNITY LEVEL

The role of renewable energy systems in a decarbonized electricity system is often analysed in terms of technology or market potential. Depending on which supporting policies are implemented, several distributed energy resources (e.g. PV, wind) are profitable and there is high market potential for ICES. However, the mere focus on technological or market potential neglects institutional requirements at community and sector level which support the emergence of ICES.

Govenance of ICES at community level relates well to Williamson’s (1998) third level of economics of institutions, which describes the ‘play of the game’, i.e. the way market actors make transactions. At the community level, the emergence of bottom-up energy initiatives relies on an organized group which either shares locality or interest, and together initiates investments in ICES infrastructure. According to Koirala et al. (2016), motivations include a preference for renewable energy and its low environmental impacts, as well as expected reductions in energy costs. Moreover, the value chain of ICES is very local, and profits from electricity generation are retained within the community. Lastly, ICES often are eligible for public funding. The opportunity to exercise control over local energy resources is another motivation for communities to invest in ICES. Despite these benefits, project initiation depends on the presence of key actors with high motivation and knowledge within the community. These take a leading role in initiating bottom-up initiatives and convince community members to invest jointly in ICES infrastructure.

ICES typically feature at least partial community ownership of the system and there must be community members willing to invest in generation capacity and infrastructure. Investment decisions depend, among others, on the anticipated amortization period. Each ICES is unique and there is no 'one size fits all' system with full investment certainty. Some potential investors in the community may be reluctant to invest, while others do not have the capital. These potential investment barriers can be reduced with customized finance products, for instance favourable bank loans or investment guarantees by the local government. Some existing ICES receive such support during their initiation phase.

3.4.1.1 FREERIDING AND SPLIT INCENTIVES

Regarding investment decisions among members, there are two economic phenomena which hinder investments: the free rider problem and split incentive problems.

The free rider problem describes the situation in which consumers of a public good understate their willingness to pay (WTP) for this product because chances are high that they will still cover their demand (Anthony E. Boardman 2010). This may be illustrated with following example: A community initiative surveys residents for their WTP for a program to install PV-powered street lighting in an area where there is no grid access. The residents have an incentive to understate their WTP so that they will not be expected to pay for this program, and they can expect to enjoy street lighting anyway if a critical mass of proponents of the program is reached. The free rider problem does not apply too much on energy in an ICES – a common good – but to infrastructure with public good characteristics which are non-excludability and non-rivalry. Within small group of actors, the free rider problem can be reduced with negotiations and contracts. At national scale, it is likely that the good will be provided below an equilibrium level, and the government can either subsidize production or provide the good itself (Anthony E. Boardman 2010).

The *split or misaligned incentive* problem occurs if benefits of a transaction do not accrue to the party who pays for the transaction (European Commission 2014). Split incentive problems regarding ICES arise for example in communities with high share of rental houses: Investments in energy efficiency measures or distributed energy resources (DER) are typically born by the building owner. Contrarily, savings from reduces energy costs are realized by the tenant. Consequently, building owners have limited incentive to invest in DER equipment or other ICES components. This poses barriers to ICES in communities where installation of a system would increase net social benefit.

ICES are organized in special ownership structures in which investment uncertainty such as from split incentive or free rider problem is minimized. In practice, there are four possible ownership structures for energy projects anchored in the community: Co-operatives, community charities, development trusts, and share owning by community members (Walker 2008). Of these, co-operatives are most common for ICES and describe an 'organization owned and run jointly by the members who share the profits or benefits' (Koirala, et al. 2016, 738). However, even in a well-established ownership structure, contracts are always incomplete. Apparently, emergence of ICES relies on factors beyond contracts and the weighing of individual benefits against costs of potential investors in the community. Ostrom (2011) describes this element as trust-building through reciprocity, which bridges members of ICES in their investment decisions. Existing ICESs are mostly present in rural areas (Walker, 2008), where there are assumingly stronger relationships between community members than in cities. This strong sense of community is favoured for example by traditions of citizen collectives and co-operatives. Certainly, this community trust is an issue of cultural identity, too.

3.4.1.2 TECHNOLOGIES FOR DISTRIBUTED ENERGY RESOURCES (DER) IN ICES

There is no single classification of ICESs and the kind of employed technologies differ between systems. However, ICES typically feature DER technologies for energy generation, which principally includes electricity, heat, or even fuels. The employed technology must be adjusted to the specific needs and capacities of the respective community, and there is no 'one size fits all' type of ICES. For instance, a rural community in a developing country which is not connected to the centralized system may choose simple, well-proven technologies, such as a mounted PV system. On the contrary, a community without tight cost limit can employ more sophisticated systems, for instance featuring automatized, IT supported demand side management (DSM) technologies, electric cars which are integrated in an electricity storage system and district heating from CHP plants. ICESs typically do not feature cutting edge technologies which are not fully technologically proven yet, or for which there is no business case established yet. This is because technologies must be bankable, i.e., there must be a certain degree of certainty for investors. Further influencing factors are the size of the community, whether the ICES is off-grid or not, the availability of favourable financing schemes and policies, and physical conditions such wind intensity, sunshine hours, and available space for generation facilities. In the Netherlands, for example, the Aquifer Thermal Energy Storage (ATES) is quite common due to the large availability of groundwater.

There are several DER technologies available which can be employed in ICES. Wind turbines, both on-shore and off-shore are technologically proven and cost-competitive with centralized energy systems. The capacity of wind turbines ranges between 0.5 and 8 MW and full load hours of on-shore turbines ranges from 1500 to 3000 MW. Offshore turbines reach loads up to 4000 hours (Itard 2012). However, wind turbines produce power intermittently and cannot be used as base load generation (Itard 2012). Hydropower provides non-intermittent power in ICESs, however, in many industrial countries, existing plants occupy most suitable sites and there are concerns on ecological impacts (Itard 2012, MacKay 2009). Biomass can be used for energy generation either in combustion power plants or to produce fuels such as biogas (Itard 2012). In agricultural communities, the use of biomass in energy generation can create a market for agricultural waste. Solar thermal power plants capture solar radiation and concentrate these with mirrors to heat a circulation fluid. Heat transfer is used to fuel a steam turbine. Solar thermal power plants require high direct solar radiation and are suitable only in regions with high sun intensity (Itard 2012), as such, they may be particularly interesting for off-grid ICES in rural communities in tropical developing countries. Capacities of solar thermal plants range from 25 to 400 MW (Itard 2012). PV cells convert solar radiation to electrical DC current. PV technologies differ in efficiency (ranging from 5 to 15%), whereas highly efficient types are more expensive to produce. The peak capacity of PV cells ranges from 60 to 150 W/m² and the full load hours depends highly on the local climate, ranging from 800 to 6000 hours per year (Itard 2012). Generation from PV cells is highly intermittent. Geothermal power plants provide a non-intermittent source of energy. These plants use heat transfer to harness geothermal heat through boreholes. Plants which harness temperatures over 100 degrees Celsius can fuel steam turbines for electricity production; however, these require high investments for deep boreholes. Plants with lower operating temperatures can be used to produce thermal energy for (district) heating or cooling (Itard 2012).

ICES may employ technologies which optimize operations of distributed generation, i.e. small scale power generation or storage which is near the point of consumption (Blumsack and Fernandez 2012). The application of modern communication infrastructure to various segments of the electricity grid -i.e. smart grid technology – can greatly increase the automation and control substations in the distribution network. The resulting connectedness between nodes in the network (i.e. points of production and consumption) increases the resilience of the network during local dysfunctions, and less users are disconnected during such events (Blumsack and Fernandez 2012). The application of communication infrastructure at point of consumption - e.g. smart meters, a bidirectional communication device on electricity demand and supply– allows consumers to make informed consumption decisions. Blumsack & Fernandez (2012) identify several opportunites from smart grid technology which are particulary relevant for ICES. The installation of smart meters allows customers to adjust their electricity demand pattern to the current rate of electricity generation (or to real-time electricity prices). If consumers shift their electricty consumption away from peak hours, the load duration curve of a system flattens and less generation capacity is required to meet electricity demand at all times. This reduces overall system costs. In an ICES with high share of renewable energy generation, a portfolio of supply-side resources in needed to compensate for intermittency. The load control abilities of smart grid technology allows the system operator to compensate for the intermittency of wind and PV. This load control is cheaper than with pumped hydro power plants or electricity storage and cleaner than with gas fired powerplants. Moreover, no new infrastructue is needed (Blumsack and Fernandez 2012). There are more benefits and opportunities from smart grid technology, yet, these are not widely used at the moment. Technologies are still expensive which hinders large scale implementation. However, they support the functioning especially of ICESs, and these technologies are likely to diseminate as soon as the institutional environment for ICES is improved.

3.4.2 INSTITUTIONAL ENVIRONMENT OF THE ELECTRICITY SECTOR

Barriers for ICES do not only exist at community level but moreover extend to the integration of systems in the technological regime. This is a highly-centralized electricity sector with top-down governance and a high share of non-renewable energy resources. ICES aim at making communities independent. Yet, most projects are connected to the existing grid as back-up for periods with insufficient DER generation and to sell generation surpluses. Only off-grid ICES are technically autonomous from the centralized grid; however, these still face institutions and sector policies which have evolved along the centralized energy sector. The integration of decentralized ICESs with focus on bottom-up governance in an institutional environment which is formed by a centralized energy sector and top-down approaches poses market barriers to ICESs. These are exemplified hereafter, whereby explanation focus specifically on the European electricity sector.

In EU countries, the electricity sector traditionally was dominated by state-owned monopolies. In this system, all five value chain segments - generation, transmission, trade, distribution, and retail – were controlled by a single company. This allowed companies to cross-subsidize between these segments and to receive monopoly rents and government subsidies for supplying their product. Starting from the 1980s, countries began to liberalize their electricity sectors to optimize tariffs and service quality, and to provide equal access to all customers. At EU level, an Energy Directive was adopted in 1996. This was updated in 2003, and in 2009, the *third energy package* was adopted. These frameworks, after ratification in national law, provide the base of a liberalized energy sector.

According to the liberalization legislation, ownership of the different segments of the value chain must be unbundled, for instance, one company cannot own both power plants and the transmission grid. This prevents cross-subsidization between business segments and eases market entrance of new companies. Moreover, third-party access to infrastructure is regulated and network operators must allow transparent access at published tariffs. In the liberalized energy system, customers can freely choose which retailer to buy from, for instance from the cheapest retailer, or from a retailer specializing in renewable energy. The implementation pace of the market reform differs among member states and is slow especially in countries with big, formerly state-owned energy companies which retain high market power. Yet, the market liberalization has introduced competition at the different segments of the value chain, and companies no longer enjoy monopoly rents nor can cross-subsidize between segments. The liberalization of the electricity sector has advanced ICES. The regulated third party access to networks makes possible the use of the local distribution network for ICES members to exchange locally produced energy. There is open market access for producers, and ICES can enter the market and compete with other producers. Under retail competition, customers can freely choose from which retail they buy electricity, which, makes possible to switch from traditional retail companies to an ICES producer.

The liberalization of the electricity sector has reduced barriers for the integration of ICES in the technological regime. Except for off-grid systems, ICES compete with other types of energy in the market, including centralized energy generation from cheap fossil fuels. There are two types of market policies which can advance the business case of DER generation in ICES: policies which increase costs of centralized generation from fossil fuels, and policies which reduce costs of renewable energy technology. The first may be an emission trading scheme such as the EU ETS, which levies a price on GHG emissions, thus, making generation from energy sources with high GHG share more expensive. The second type includes policies which aim at promoting the use of renewable energy directly, such as feed-in-tariffs. FITs for renewable generation can promote ICES especially if the net generation costs without subsidy are persistently higher than market clearing price at the electricity market. Here, the FIT closes the cap to market competitiveness, thus, advances the business case of ICES, which lures in investments.

There are many more issues which restrain ICES in the market than the ones described above. After all, the institutional environment of the electricity market has evolved along a highly-centralized system. According to Williamson (1998), the institutional environment describes *"(…) the rules of the game within which economic activity is organized. The polity, judiciary, and bureaucracy of government are all located here"* (Williamson 1998, 27). In other words, regulations provided from politics, jurisdiction, and bureaucracy still presume a top-down, centralized energy system where a centralized authority controls all major system elements and operations (Finger, Groenewegen and Künneke, The Quest for Coherence between Institutions and Infrastructure 2005). This institutional environment in part fails to accommodate decentralized systems such as ICES, in which decision making is distributed throughout numerous agents, and where system coordination is realized by certain institutional arrangements without active planning or direct intervention (Finger, Groenewegen and Künneke 2005).

3.4.3 ECONOMIC, ENVIRONMENTAL AND SOCIAL ADVANTAGES OF ICES

ICESs are an option to gradually innovate the current institutional environment of the energy sector. This is desirable because of the involved potential benefits in terms of more efficient energy usage, local economic gains, low carbon energy consumption, and improved social cohesion at community level.

Most energy benefits derive from the fact that energy systems are integrated. This applies not only to electricity but also to heat, cooling, transport, etc. Therefore, a higher optimisation of resources in different areas is possible, which improves energy efficiency (Koirala, et al. 2016, Databuild Research & Solutions Ltd 2014). One way of doing so is by allocating energy quality to adapt it according to its application. This may be for example using solar heating to warm up buildings and households instead of burning fuels or using electricity (Council of Energy Ministers 2009). Another way is the option to allocate land-use to reduce and concentrate energy demand (Council of Energy Ministers 2009), which will diminish energy losses as energy will travel shorter distances (Koirala et al., 2015). Integration also contributes to enhance demand response, which will improve local balancing (Koirala et al., 2015).

In terms of local economy, with all the work that must be done in the community to design, install and manage diverse components of an ICES, many jobs are created (Council of Energy Ministers 2009). This benefits the community and its surroundings, as the money spent in energy stays local and boosts the economy, which leads to more investment in the area (Vaughan 2015). Furthermore, two main aspects that attract people to develop an ICES are: lower energy costs and a source of income. The former is achieved through less energy imports and more stable energy prices. ICESs generate income to the community through feed-in tariffs (FITs) and through ownership of commercial energy developments (DECC 2014).

Communities that apply ICES are able to improve their self-sufficiency, as they will have more control of their energy management (Databuild Research & Solutions Ltd 2014). This in turn, can make the community more sustainable with a lower carbon footprint (Databuild Research & Solutions Ltd 2014) as a result of reduced CO2 emissions (Council of Energy Ministers 2009), mainly due to larger energy production from renewable sources instead of fossil fuels. Therefore, ICES provide an effective option for a low carbon energy transition (Koirala, et al. 2016).

According to the British Department of Energy and Climate Change (2014), the social benefits that are not commonly considered when analysing ICES are: stronger communities and skill development. Cooperation in energy projects is likely to unite and strengthen a community as they work in a common cause and are empowered to find solutions to local problems. However, it is important that the whole community is involved, which might be a challenge. This is why it is very important that organisers and volunteers are fully committed (Databuild Research & Solutions Ltd 2014). In addition, community members can gain useful skills that can range from managerial roles to technical abilities through their work on energy projects.

4 METHODOLOGY

For this project, the research questions are addressed by a comprehensive approach consisting of multiple research methods. These are briefly explained in the following paragraphs. We moreover use the theories that were introduced in chapter 2 throughout our research. Phase 1 is a case study description. Phase 2 of the research is an empirical analysis focusing on the variables of the SES framework in order to provide a basis for answering question 1 a, b and c. Phase 3 of our research describes the contribution we make to facilitating ICES and answers the research questions 1 and 2. For phase 4, the influence of selected STS variables on the implementation of ICES was modelled using agent based modelling. See Figure 5.

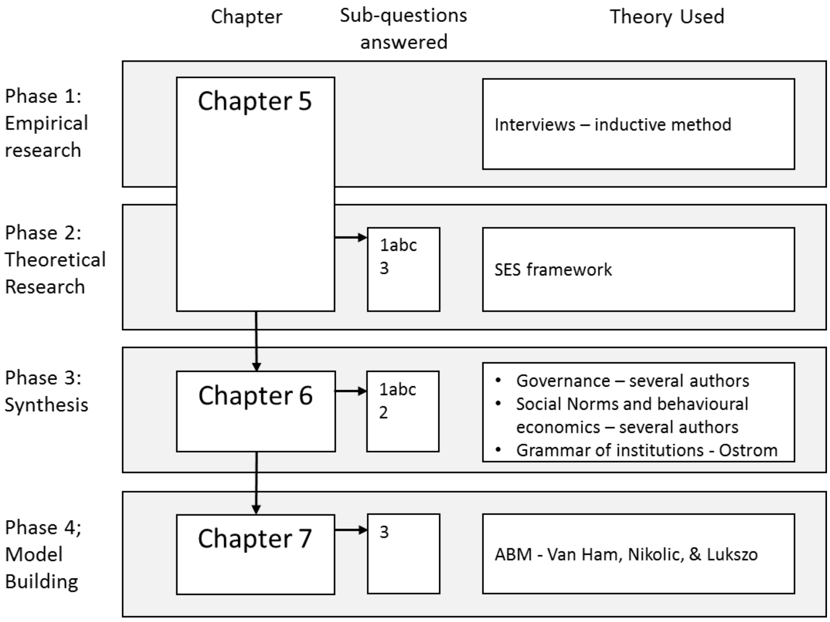


Figure 5: Phase structuring

4.1 PHASE 1. CASE DESCRIPTION

In this phase, a general description of the selected case study was given. Apart from a general description of how the DE Ramplaan is structured, a general overview of how the idea and project itself was developed is provided. The information was gathered trough desk research.

4.2 PHASE 2. EMPIRICAL ANALYSIS

The SES framework served to examine the case in more detail. The first-tier variables were described based on research conducted on the Dutch energy policy and institutions.

The second-tier variables were described based on the SES framework, desk research and interviews. Every variable was evaluated based on its relevance to the case study. This way, both relevant and irrelevant variables became apparent.

The information generated from the desk research was complemented with information gathered through interviews. Particularly, for information regarding governance, the responsible cooperative leaders were consulted. This research method was qualitative, which is a method particularly useful for retrieving information regarding perceptions, experiences and emotions (Hennink, Hutter en Bailey 2010). The interviews were semi-structured: open questions were asked, loosely based on several theoretical concepts. The order of questions was adjusted when needed, and follow up questions were asked. This method is known as an *inductive process*, where reasoning happens from a specific situation to a more general conclusion (Copi, Cohen en Flage 2007). The summaries from the interviews are presented in the Appendix section of this document along with the list of interviewees.

4.3 PHASE 3. CONTRIBUTION TO FACILITATING ICES

This phase is presented by chapter 7 and provides a definite answer to question 1 and question 2. A modified version of the SES framework is presented to fit the analysed case. Using the modified version, a method for facilitating the case in retrospective is proposed by rearranging the modified framework variables into steps. For each step key variables were selected.

The key variables were chosen because they either come to represent best desired outcomes or because they are necessary for decision making. To justify the importance of such variables and give insight into how to get the best result out of them, acquired knowledge on theories from social scientist like Biccieri (grammar of society) and Ostrom (on grammar of institutions) was used. However, other authors and other topics from the industrial ecology background were cited and explained in the form of available tools to improve variable performance.

The method was assumed to be generalizable and thus provided the basis for phase 4.

4.4 PHASE 4. MODELLING

In this phase, a simple agent based model was built to explore how the variables - identified and selected through phase 1 until 3 - will influence decision making. Agent based modelling is deemed an appropriate tool to conduct such analysis due to its capacity to represent entities which perform actions and make decisions, and effectively interact with their environment (van Ham, Nikolic and Lukszo 2013). The results that were extracted from this model were used to reflect which constitutional rules are essential to ensure successful implementation of ICES.

5 THE RAMPLAAN CASE DESCRIPTION

To analyse to what extent the SES framework can be applicable to a socio-technical system a real-life case study in the Netherlands was examined. This section will describe the case and elaborate on the case description, the participating parties, the organization and financing and additional documents. These will be subdivided into three separate parts: the elements that resulted in the obtained knowledge, the beginning stages of the project and the actual development and actualization of the project. The content of the research will be described in this section.

5.1 ELEMENTS OF THE CASE DESCRIPTION

During the desk research phase information was gathered from a high-level business case describing the technical and financial possibilities of the Ramplaan. This business case was developed and financed by the municipality and used for further decision making. It was used as foundation for this analysis, and further research was done according to this business case. Next to this the available information online was used, both presented by the source itself as well as media articles. Lastly, three interviews were conducted with experts on the specific events that occurred and the governance of the Ramplaan and ICESs.

To gather more information on energy collectives an interview was conducted with Merian Koekoek who is a project manager at HIER Opgewekt, the knowledge platform on energy cooperatives for sharing knowledge and information. She provided a lot of background information on how the implementation of an energy cooperative goes and what obstacles usually have to be overcome.

For further information on the specific Ramplaan case two interviews were conducted. One with one of the former members of the Ramplaan Foundation, Sabine Janssen, and with the chairman of the Ramplaan cooperative Eise Jan Wattel. Both gave more insights and details on the development and set-up of the case. The high-level business case was very elaborate on the financial and economic situation, so during the interviews focus was put on the governance and social elements of the project.

5.2 IDEA DEVELOPMENT THE RAMPLAANKWARTIER

5.2.1 THE START OF THE RAMPLAAN PROJECT

The built environment in The Netherlands accounts for 35% of primary consumed energy. Ramplaankwartier is a municipal area in Haarlem with more than 1000 homes which are representative for large part of the residential areas in the country. (Jansen, et al. 2012)

In 2014 the governmental body of Haarlem presented their governing plans for the following 4 years in the municipality. The governing parties propose a plan to make Haarlem climate neutral per 2030, aiming at energy, resources, climate, water and air quality. (Gemeente Haarlem 2014) In earlier years the municipality had already proposed plans to become more sustainable, but due to numerous local initiatives and inhabitant enthusiasm the municipality has decided to upgrade their plans. One of the earlier initiatives was the Ramplaan case, located at the Ramplaankwartier neighbourhood. Figure 6 shows the location of Haarlem and the Ramplaankwartier.

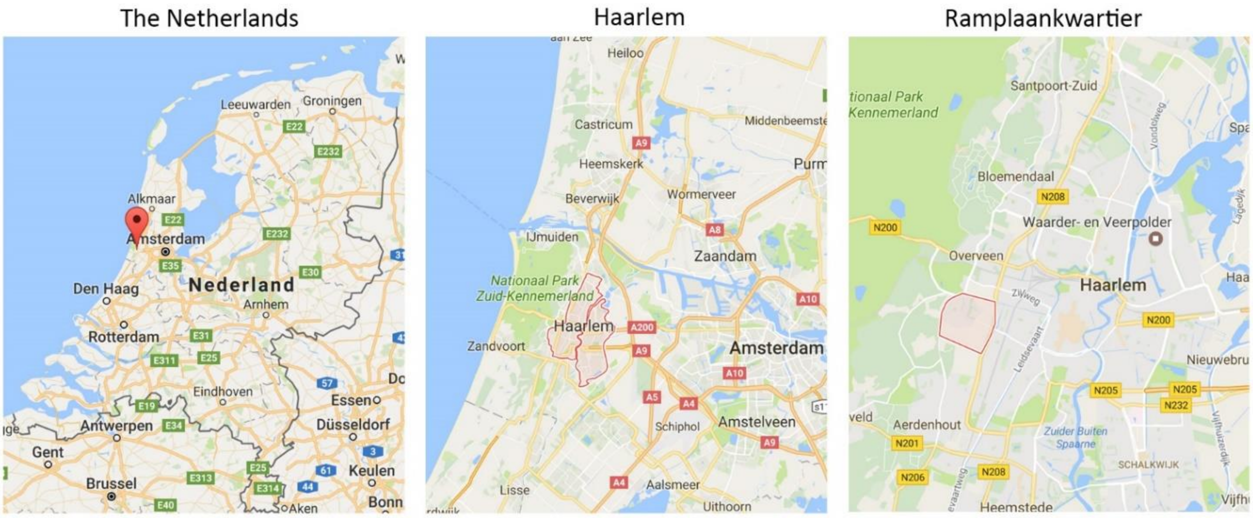


Figure 6: The location of the Ramplaankwartier neighbourhood in The Netherlands

5.2.2 THE RAMPLAAN FOUNDATION

In 2011 a group of enthusiastic residents of the Ramplaankwartier, a neighbourhood in Haarlem, decided to put effort in improving the sustainability of their neighbourhood. Later that year, led by Jim Streefkerk, a foundation was set up to maximize the sustainability in the Ramplaankwartier by doing research, taking measures and improving awareness and attitude of the area's residents. They named the Foundation Stichting DE Ramplaan[1]. The main aims of the foundation were as follows:

Goal 1: Decreasing energy use by 12.5 % from 2012 onwards.
Goal 2: Increasing the share of renewable energy technologies on private roofs.
Goal 3: Improving the reuse/circularity of materials and products in the area.
Goal 4: Researching the feasibility and applicability of sustainable techniques.
Goal 5: Maximizing the percentage of engaged residents and local businesses.

Already in 2012 the Ramplaan Foundation engaged in conversations with the Fablo tennis court, owned by firm Thoolen. This tennis court had a roof surface are of ca. 6500 m^2 and a 50% south-west orientation. (Jansen, et al. 2012) The tennis court is located in the nearby area and was chosen to locate the solar PV installation, see figure 7 and figure 8. During this time the first quotations for the restauration of the roof and the solar PV cells were requested.

[1] DE Ramplaan stands for Duurzame Energy Ramplaan (Sustainable Energy Ramplaan), but for the ease of this case we will refer to the foundation as the Ramplaan Foundation.

Figure 8: The location of the Fablo tennis court

Figure 7: The roof of the Fablo tennis court

5.2.3 THE HIGH-LEVEL BUSINESS CASE

To support further development of sustainable technology implementation the Haarlem municipality commissioned a research by the Energy Transition Group to conduct a technical and financial feasibility study comparing several scenarios for a locally sustainable Ramplaankwartier neighbourhood. The goal of this business case study was to evaluate whether the neighbourhood's current expenses of energy could be lowered by a transition towards locally produced sustainable energy. The ambition is to use the savings generated by this transition to invest in the cooperative, therefore being able to sustain the transition without any extra financial burden on the users of the cooperative, aiming at a maximal payback period of 10 years. (Jansen, et al. 2012)

The business case was developed for three different scenarios, which are stated in table 1. Every scenario was evaluated on both technical and financial feasibility. The following technologies were considered: solar PV, wind turbines, biodigester, heat and cold storage or WKO[2], heat from greenhouse gases, and again heat and cold storage from fossil fuels or WKK[3]. For these technologies, the technical and financial feasibility was evaluated for reducing the CO_2 emissions (both for housing and enterprises) to zero. (Jansen, et al. 2012)

[2] WKO = Heat and cold storage technology

[3] WKK= Cogeneration

Table 2: Scenarios evaluated for Ramplaankwartier Haarlem

Scenario	Description	Investment needed	PBP	NPV
All electric (no insulation)	Energy need, including space heating and hot tip water is fulfilled through renewable electricity (with or without insulating the houses)	€ 23 million: • Homes: 19.2 • EC DE Ramplaan: 4.1	2028	€ 23 million
All electric (insulation included)		€ 36.5 million: • Homes: 32.4 • EC DE Ramplaan: 4.1	>2032	€ 13 million
Maximum sustainable	Electricity and heat are generated in sustainable fashion, including waste processing.	€ 42 million: • Homes: 25.8 • EC DE Ramplaan: 15.7	>2032	€ 11.1 million

It was concluded that all three of the scenarios stated in table 1 are technically feasible. Reducing the CO_2 production from 5.400 metric tons per year for houses and 21.000 metric tons per year by enterprises can be achieved through a combination of energy saving measures in buildings and a sustainable production of heat and electricity.

The financial feasibility numbers show that the desired payback period of 10 years is not feasible in any of the three scenarios. The all electric (without insulation of houses) scenario comes closest with a payback period of 11 (capital costs excluded) and 13 years with capital costs included[4]. The all electric extended & maximal sustainable scenario requires two payback periods of 16 and 20 years respectively. Internal rates of return suggest that the first all-electric scenario is bankable directly, while the other two scenarios are not bankable without any supplementary government securities or subsidies.

In the Haarlem case, the resource system is comprised of several energy producing entities. The "size" of the resource is defined by the installed capacity. The Ramplaan case consists of the following energy producing (or saving) technologies:

- Solar PV: 76.6 kW capacity
- Wind energy: 800 kW capacity
- Green modem (energy from waste and biomass) 2,4 kton wet feedstock
- Aquifer thermal energy storage: 2500 kW
- Synergy greenhouse: surplus of waste heat of 22.000 GJ per year.

The high-level concludes that the Ramplaan project is consistent with these types of initiatives and will likely be eligible to receive government support, make local sustainability contributions and stimulate local construction and communal engagement. What the case shows is that there is plenty of opportunity to implement sustainable technologies. However, for the actual realization of the project, one step was taken, where only the solar PV aspect was implemented. So, only the PV energy production was analysed throughout the rest of this report, because there is no other technologies implemented yet.

[4] For this case study, an interest percentage of 3% was used. However, recent interest rates are considerably lower. Hence, for recent energy cooperatives lower interest rates might be more realistic.

5.2.4 GOVERNMENTAL INPUT

Throughout the process the municipality of Haarlem was closely involved with both the Foundation and cooperative, both in funding and in expertise. Also for member the solar panel investment could be pre-financed by the government and paid back via a loan (Wattel 2016)

Begin 2014 the Dutch government implemented a policy, the Postcoderoos. The Postcoderoos allows for a tax reduction in the energy bill and participants will receive compensation for the project they are taking part in. What this policy allows for is that that residents who do not live in the direct area of the project, but do share the almost similar postal codes are still allowed to join the initiative. See Figure XX for the joining areas.

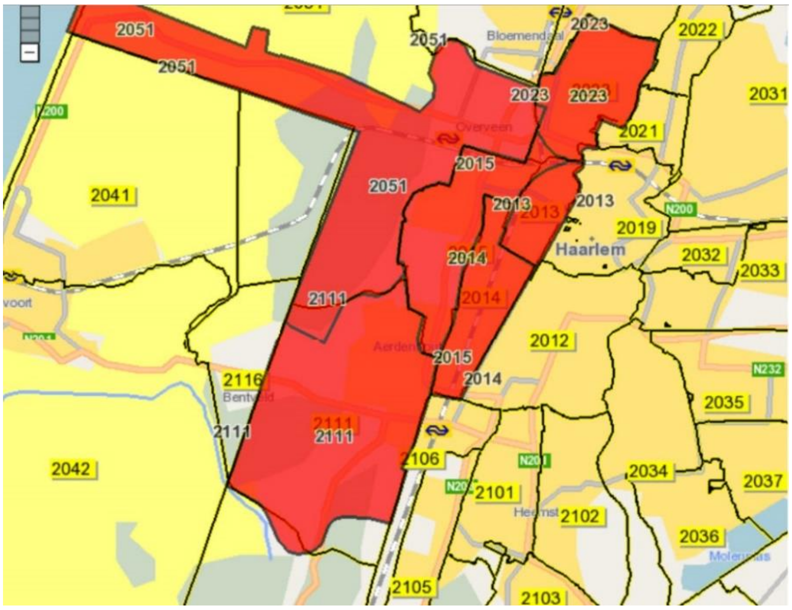


Figure 9: The postal codes that are allowed to join the project according to the Postcoderoos policy

As the tennis court has the largest solar PV roof in the Netherlands, the cooperative stood for the biggest Postcoderoos-project so far. This discount to energy taxed was, however, not immediately financially attractive. This policy was derived from the energy agreement signed by 40 national organizations. The agreement tries to promote local initiatives trying to generate renewable electricity. The Ramplaan case was one of the first initiatives applying for the policy. (RVO 2016) At first the policy was still too tight by only giving a discount of 7.5 cents/kWh, but due to the lobbying activities of the cooperative and other energy initiatives better tax reductions to result in negligible energy taxes were realized to make such initiatives financially feasible (HIER Opgewekt 2016) Additionally, the lobbying also resulted in a discount for ten years, instead of only four years where small business could get higher discounts. (RVO 2016)

5.3 PROJECT DEVELOPMENT THE RAMPLAAN PROJECT

5.3.1 THE COOPERATIVE

After the developments so far and the implementation of the governmental policy, there was the need for the Foundations for a separate entity to execute the ideas and realize the actual project. By sending out email they requested for interested new board members for the area. April 2014 marked the official start of the Cooperative DE Ramplaan, further referred to as the Ramplaan cooperative. During this year the campaigning for the solar power parts started and a contract with distribution service operator was set up. Late that year the Fablo tennis court roof was renewed.

Beginning 2015 all member that had enrolled previous year agreed on the plan of the cooperative and the construction stated. September 2015 the official solar power plant at the tennis court was opened with success. The following year the cooperative focused on improving their communications, setting up a system for trading or selling solar power parts and managing the cooperative to stay stable for the coming 20 years. At the moment the board is preparing for taking future steps, but what will happen with the cooperative after the successful implementation is still uncertain. (Wattel 2016)

Although the Foundation initiated the project and developed the first plans, the cooperative soon took over the project, recruited the members, arranged the contracts with other stakeholders and became responsible for the juridical and economic property of the solar power plant. To be able to handle contracts and get official governmental approval the cooperative became a legal foundation.

The cooperative was led by business economist Eise Jan Wattel, manager operations at TATA Steel Europe. According to him, it was very important that the team consisted commissioners with the same drive, but more importantly expertise in different fields. (Wattel 2016) Next to Wattel, the board consisted of econometrist Jeroen Vijverberg, sociologist Stijn Ruiter, electrician and company director Dion Gigengack and communication specialist Art den Boer. The board is supported by the advisory board that had additional knowledge on long-term energy predictions, complex contracts, politics, energy policy and consultancy. The work took each board commissioner about 6-8 hours a week during the preparation and implementation phase. At the moment, some administrative and communication task only take the commissioner 1 hour a week.

Figure 10: The flyer promoting membership for the Ramplaan. Retrieved from (RVO 2016)

Throughout the set-up of the project the board was in close contact with the municipality to discuss funding and all possible option. The high level business case was used as a starting point. After intensive negotiations the final set-up was decided upon and first members were recruited. Subsequently the cooperative spent each Saturday that year at a stand with flyers trying to recruit members, see figure 10.

5.3.2 THE SET-UP OF THE SOLAR POWER PLANT

In total the roof of the tennis court houses 1607 solar panels of 275 Wp. The expected production laid around 400.000 kWh/year. Since there was no funding for the project, the investment had to come from the members themselves, aka the inhabitants of the Ramplaankwartier. To facilitate this participation model, the cooperative divided the energy production into so called 'solar power parts'. Each solar power part stands for an energy production of 225 kWh/year. Member we allowed to buy multiple solar power parts, but had to finance at least two parts. One solar power part cost €325. The electricity produced at this small power plant is monitored by Qurrent and put back into the grid where the grid operator Liander managed the energy. To be able to facilitate a pay-back system for the members that invested in the solar panels, the cooperative negotiated with Qurrent to offer cheaper contracts. So next to investing in solar panels the members had to transition to Qurrent as their energy provider and place a meter in their house. This enables Qurrent to translate the electricity production each member was responsible for back in form of a discount on their annual energy bill. Figure 11 shows how the transactions work within the Ramplaan case. There are no other steps required by the members. The collective was very focused on making the effort for the members as small as possible to get most people to join. (Wattel 2016)

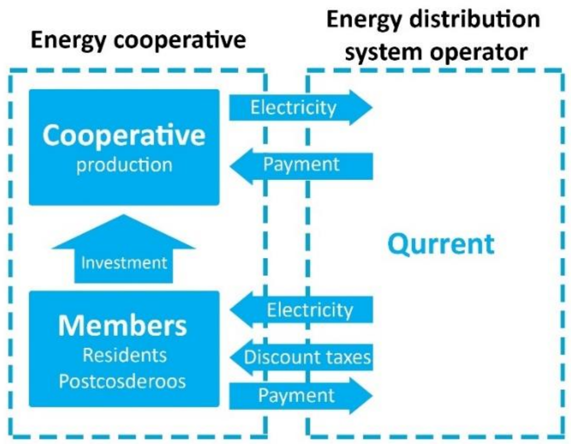


Figure 11: The transaction model of the Ramplaan project. Adapted from (RVO 2016).

5.3.3 MEMBERSHIP

Trust from the members was a key issue, since their subscription meant that they agreed on investing without knowing the exact payback time of their investment. The total investment resulted in €450.000 euros. Depending on the negotiations, the Postcoderoos policy, the amount of members and the expected electricity production, the cost for one solar power part was determined. This then turned out to be between 10-15 years, but at that point most members had already joined the cooperative. A membership thus consisted of three elements: a formal contract, an investment of €325 per solar power part and a contract with energy provider Qurrent.

Figure 12: Voting during a member meeting (DE Ramplaan 2016)

In return each member has an equal vote in the decision concerning the cooperative and is, depending on their investment, partly owner of the solar PVs, see Figure 12. It was deliberately chosen that each member, regardless of the investment made, has an equal vote. This was, voting for self-interest was allowed, but the chance that the largest investor would get their way was decreased. Also, the cooperative felt making this decision was best for the governance and the unifying feeling amongst all members. They are all individuals of the neighbourhood and should also count like when making a decision according to Wattel (2016).

5.3.4 MAIN STAKEHOLDERS

To be able to understand the current structure the whole Ramplaan project it is important to know all the stakeholders involved. Although there were many smaller stakeholders that have influenced the process, the main stakeholder that were engaged and how they are connected is shown in the stakeholder map of figure 13.

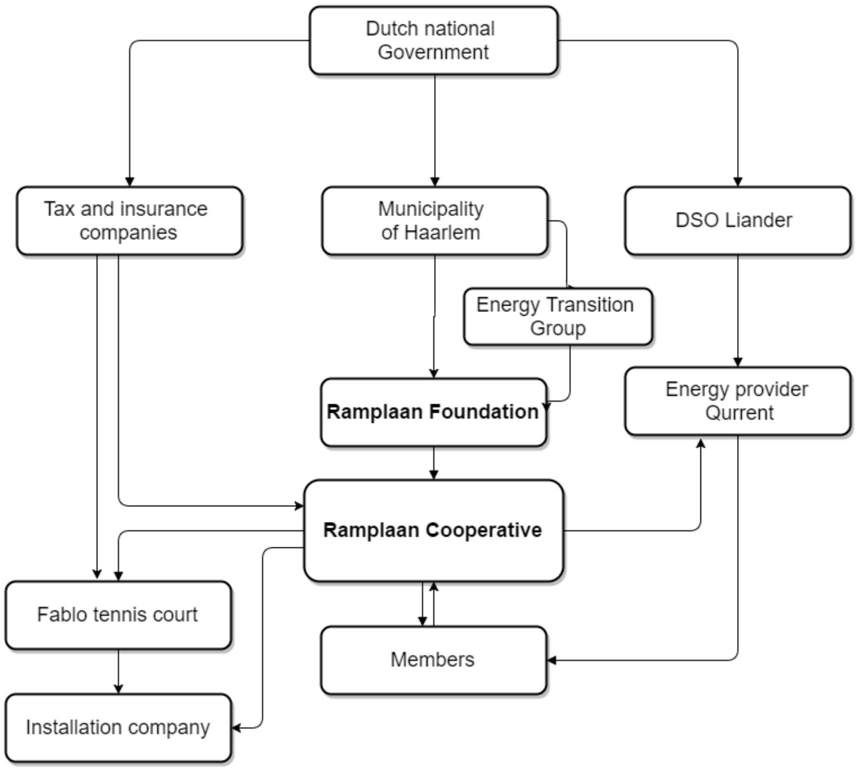


Figure 13: The stakeholder map of de Ramplaan showing the main direct actors

6 EMPIRICAL ANALYSIS: SES FRAMEWORK APPLICATION

In this section the Ramplaan case study is described using the SES framework. We explain each variable and explain how they can be translated to the Ramplaan case. This process allowed us to determine whether all variables are applicable for the study of an ICES, if they should be altered, or if new variables should be added. The chapter is divided into each variable system. Each section starts with a table describing all the sub variables belonging to the variable system and the case related description. The table then is accompanied by a wider explanation on the current situation of the Ramplaan as a ICES. For the descriptions, relevant information from the high level business case, online documents and the three conducted interviews were used.

6.1 GROUP 1: SOCIAL, ECONOMIC AND POLITICAL SETTINGS

The social, economic and political setting is the context by which the case study is affected. The connection between all three elements determines the initial setting for the dynamics of an ICES. For the Ramplaan case the setting is based on an already existing community where the foundation and cooperative have decided to transform the community into a ICES. The fact that the infrastructure and community have not been built to become and ICES had influences on the success. The contextual system is comprised of seven variables specifying all aspects important as seen in the following Table.

Table 3: Social, Economic and Political Settings

SES Variables	Case study situation
S1 Economic development	Wealthy situation due to high middle class households.
S2 Demographic trends	Family houses from the early 20th century, members mainly aged 35-45.
S3 Political stability	High: stable party coalition and supporting municipality.
S4 Other governance systems	Not at local level, but there is great influence from the national context.
S5 Markets (market incentives)	National and local sustainability goals and policies have influence over the area.
S6 Media organization	Mouth to mouth invitations, and use of flyers.
S7 Technology	Mostly reliable on the regional grid. Only 10% of households own solar roof PV.

S1. Economic development

The Netherlands is considered as a country with a strong developed economy. The Dutch economic outlook is stable, with an expected 2% GDP growth in 2016. This is mainly due to better labour market conditions, a stronger housing market and brighter business prospects. Inflation is expected to grow slowly (OECD 2016). This is regarding national context of Haarlem within The Netherlands. Specifically, in the Ramplaan neighbourhood, the families living there can be considered high middle class, wealthy in general terms, leading to believe their economic development can be considered positively stable. (Wattel 2016)

S2. Demographic trends

Haarlem had an estimated population of 158,000 inhabitants at the beginning of 2016 (Thomas Brinkhoff 2016). It is the capital of the North Holland province and is the 12th largest city in the Netherlands (Central Bureau voor de Statiek 2016). The average age is 41 years; 49% of the population is made up by men and the remaining 51% by women (UrbiStat 2016). Education levels in Haarlem are similar to the Dutch average: quite high, with an average of 32% of the population between 25 to 64 years old with a university degree. About 51.2% of Haarlem inhabitants own their dwellings, while 48.8% rent (35.3% in the social sector and 13.5% in the private sector (OECD 2014). The Ramplaankwartier is a small city neighbourhood that has clear physical boundaries so easily loans itself to become a community. And since almost all inhabitants own their house, they tend to build up long-term relationships with their next door neighbours. (Wattel 2016) The city has a large amount of pre-war housing (51.7%) which are typically small, not well insulated but aesthetically pleasing.

S3. Political stability

The Netherlands has a quite stable political system. The average of the country in the political stability index is 1.1, which makes it well situated as the index's values go from -2.5 being weak, to 2.5 as strong (The Global Economy 2016). Politics are based on negotiation and consensus instead of conflict. Haarlem also has a strong political stability. It is currently governed by a coalition of four political parties who are centre-left oriented. The left party is, in general, in favour of environmental policies. The political parties are Groenlinks, PvdA, D66 and CDA (Gemeente Haarlem 2016).

The political stability of the foundation and the cooperative itself is dependent on the interaction and the engagement of it board. Both boards are voluntarily which puts pressure on all members and required a large portion of enthusiasm. However, because for most individuals this was the main drive to join, keeping each other motivated did not appear to become a problem. (Wattel 2016)

S4. Other Governance Systems

Besides the foundation and the energy cooperative, there are some other local governance systems related to energy topics regarding the Haarlem area. However, at the moment they have no connection yet. Thoughts are to start working together in the future, but there are no concrete plans yet. However, national and international organizations have influence at the local level as well. These are the Dutch ministry of Economic Affairs (EZ) and the European Union.

EZ began an energy transition management process in 2000. Three sustainability criteria were developed: security of supply, economic efficiency, and minimal environmental and social impact (EZ 2000). The ministry had among its goals, to achieve new efficient and green gas, and to modernize energy supply chains to make them more efficient. To achieve this, it adapted the financial structure, removed institutional barriers, and created a platform for continuous learning. Changes in the financial structure included instruments for financing of projects that provide innovative transition experiments for renewable energy, according to Loorbach (2008). Initiatives such as the Ramplaan case benefit from this.

Concerning the influence from the European Union, there is a strong incentive for the Dutch energy system to largely increase its share of renewables, as in the Renewable Energy Directive (2009/28/EC), final energy consumption should represent 14% of renewables by 2020 (EEA 2013)This is why renewables have guaranteed access to the grid (EEA 2013). However, this is a challenge. In the Netherlands, the large amount of energy-intensive industries (e.g., refineries, iron, steel and chemical sectors) influence the energy system. This is evident from the tax rates on natural gas and electricity, as energy intensive companies benefit from lower taxes than households and SMEs (Small and Medium Enterprises). The tax structure is regressive, so the higher the consumption, the lower the rates (PBL 2015). This policy aims at preserving the competitiveness of the industrial sector in the Netherlands.

S5. Market Incentives

According to the Netherlands Environmental Assessment Agency (in Dutch Planbureau voor de Leefomgeving, PBL) (2015) the Dutch government fosters self-generated renewable energy to smaller users like households. The latter are exempted from the energy tax when they consume electricity from renewable sources. Also, smaller users can use net metering, which means that the connection to the electricity grid is billed according to annual net energy use, so people only pay for the result of the kilowatts taken from grid minus those put into the grid. Additionally, since January 2014, "members of community energy cooperatives and associations of owner-occupiers within a given postal area are eligible for a tax reduction of 7.5 eurocents/kWh for collective renewable electricity production" (PBL 2015, 25).

The Dutch government stimulates investments in renewable energy through three instruments: a Feed-In Premium (FIP), the Energy Investment Allowance (EIA) and a biofuel blending requirement for transport (bijmengverplichting). Altogether they are called Stimulering Duurzame Energieproductie (SDE+). Solar photovoltaic (PV) projects can apply for the SDE+ benefits only if they are large scale, which excludes households. Still, the subsidies are too low to cover for the difference between generation costs and market prices. This has limited the amount of solar PV generation in the country (EEA 2013). All of this is the context applicable to the Ramplaankwartier neighbourhood: although there are market incentives to further develop their ICES, there are several barriers to overcome.

S6. Media organization

Concerning the Ramplaankwartier neighbourhood as an ICES, communication has been achieved through mouth to mouth advertisement in the beginning, and the distribution of flyers. The first meetings of the foundation took place at the local church where email addresses were collected through which board members were recruited for the cooperative. (S. Jansen 2016) The cooperative enlarged its community base by distributing flyers and also collecting email addresses and promoting early membership enrolment each Saturday at a public place. (Wattel 2016)

S7. Technology

It can be assumed that the Netherlands has access to all necessary technology for developing renewable energy systems and for implementing the most popular ones like: wind turbines, solar PV panels, biomass, cogeneration of heat and power (CHP), heat exchangers, heat from greenhouses and using waste to produce oil or gas. Also, technologies for monitoring like smart meters are available. The smart meter approach in the Netherlands is called Power Matcher, and it will improve the efficiency of renewable energy, as consumption can be matched with generation, so green energy use can be maximized in the community. (P. B. Koirala, et al. 2016) The same is applicable to the Ramplaan case.

6.2 RESOURCE SYSTEM

Since the STS is being evaluated as if it were a SES (Ostrom, 2009; Geels, 2004), the resource that is being discussed might not be entirely clear; we are talking about a “constructed resource”. In the Ramplaan case the resources system is the ICES. The constructed resources derive from a primary resource providing energy (solar radiation); which then, is made available by the energy producing technology (electricity by solar PV); and finally, is put back into the grid in the form of electricity. Depending on the investment of the member this is later shown as a decrease in the energy bill. Thus, the resource system includes the resource units, which we defined as the energy generated by each type of installed technology. It also has to include the common pool resource. This, we set as the maximum amount of energy that the combined energy technologies in the ICES can provide. Although in DE Ramplaan only one technology (solar PV) has been implemented, the expectation is that the system will become more complex in the future. As the theory on ICES suggest, the technology is adapted to the community’s needs.

Besides the energy resource, the resource system includes the prosumers, the installed technologies and the energy cooperative leading the project. In the SES framework, it is described by 8 variables as seen and briefly described in the following table.

Table 4: Variables associated with the Resource System

SES Variables	Case study situation
RS1 Sector	Energy in a neighbourhood
RS2 Clarity of system boundaries	Boundaries set by: households in the Ramplaan neighbourhood and membership to the Energy Cooperative DE Ramplaan.
RS3 Size of resource system	Defined by the capacity. Solar PV on roof area generates about 400 MWh yearly.

SES Variables	Case study situation
RS4 Human-constructed facilities	All is human constructed. In this case: solar PV system on roof areas.
RS5 Productivity of system	Linked to installed capacity. Currently consists of 1609 solar power parts, each with the power of generating 225 kWh per year.
RS6 Equilibrium properties	Not considered since the resource system is connected to the regional grid, which is the one dealing with equilibrium: supply meeting demand.
RS7 Predictability of system dynamics	Predictable on the basis of weather forecast.
RS 8 Storage characteristics	No storage on site, but connection to the grid assures all energy produced is stored in it.

RS1 Sector

The resource sector is the energy sector, specifically decentralized energy generated at community level. Since the current produced electricity is only generated by PV cells, the sector is bound to the electricity grid that is enables by Qurrent and Alliander.

RS2 Clarity of system boundaries

The system boundaries in Socio Ecological systems are mostly defined by physical barriers (e.g. the development of lake shores and surroundings) (Bal 2015). Within socio-technological system, problems can arise with respect to the clarity of the boundaries of these systems since it is all human constructed and not necessarily tangible. For the Ramplaan case, the system boundaries are understood to be clear. The extractable resource is energy produced by a solar PV collective roof owned by the members of the local energy cooperative. Thus, the system boundaries of the produced energy are given by owning a share in the energy cooperative. This gives access or ownership to either a part of a collective solar roof, or to install the parts on a private roof. In any case, only those households who are members of the energy cooperative are considered part of the resource system boundary.

However, in order to get more members, the cooperative allows residents from outside the physical area to become a member through the national policy called the Postcoderoos. The factors that define these system boundaries are users (households) and formal connection to the resource system (energy cooperative membership).

RS3 Size of resource system

The SES framework seems to suggest a physical defined size, and Ostrom argues that moderate territorial size contributed most to successfully govern that resource. But when it comes to socio-technological systems, the size is not determined by the physical boundaries only, but more so by the member of the cooperative and the production of the PVs. Several indicators could be considered. In the Ramplaan case, the resource system is comprised (at the moment) by 1349 solar panels, or 220 prosumers, or 1609 solar power parts. However, we consider that the best way the system can be technically described is by its installed capacity.

RS4 Human-constructed facilities

The relevance of the human-constructed facilities in socio-ecological systems is evident because human facilities enhance, destroy or otherwise interact with a natural resource. In the Ramplaan energy system, most facets of are human-constructed facilities where solar PV panels are used to convert solar energy into electricity. Furthermore, the areas where the panels are installed are human constructed as well (houses or collective tennis court roof). It is noteworthy that the majority of common resource pool elements are anthropogenic, while classic commons (forest, fish stock, grazing land) consist of natural resources by large.

RS5 Productivity of system

A case study concerning lakes in India (Bal 2015) defines the productivity of the system as its regenerative capacity to produce the required function. From exact sciences, we know productivity is simply defined as a ratio between the produced output, and the input required to produce it. In either case productivity of the system in ICES will be dependent on the installed capacity. Several indicators could be used to describe the system´s productivity, but we consider it should take into account the community´s objective when creating the ICES. If for example, the long term objective is that capacity meets the total demand at all time as described in the high level business case, the expected productivity would be 1.8 MWh per person per year; likewise, total avoided CO_2 emissions would be 15.90 kg/person/year, according to Jansen et al. (2012). So far, productivity is not being targeted within the cooperative members. Initially, the idea was to get as many members as possible and to be able to give an affordable option to them. The implementation of the PV technology resulted in a production of 225 kWh per year and cost €325, per part, with a payback period of 10 to 15 years.

RS6 Equilibrium properties

The equilibrium in SES is an amount of resource extraction at which constant or sustained productivity in the system is maintained. In this ICES however, distinctive from a natural resource system, no equilibrium has to be met. There is a constructed capacity which is set beforehand, based on the community´s objective. But this variable can be relevant in a different context. If it were a closed system, where supply had to meet demand, equilibrium would become key. But again, this is not the case for the DE Ramplaan. The households are connected to grid, and thus, the community is not concerned with achieving or maintaining equilibrium. Although some ideas are being developed to get off the gas grid, the focus has now only been on the electricity production through PV cells.

RS7- Predictability of system dynamics

System dynamics refer to the behaviour of the system in time, and according to Bal (2015), they “need to be sufficiently predictable that actors can estimate what would happen if they were to establish particular rules” (p162). Concerning the Ramplaan case, the system is predictable from a technical perspective. The solar panels are expected to function at all time, producing an amount of energy dependent on the daily radiation input. But predictability of the system also concerns the prosumers, the decisions they take which can have an impact on the ICES. At the moment the system is stable: only one technology implemented, and connected to the grid with a constant functioning. As for predictability, this is an unexplored subject. In the words of the current chairman of the Ramplaan cooperative Eise Jan Wattel (2016), “the main goal in the first place was to get the system up and running”, which they have achieved; “the next step is to discuss what we want in the future”.

RS8 Storage characteristics

Storage has great influence over the predictability of the system when it comes to energy systems. Electricity cannot be stored in the Ramplaankwartier, since no infrastructure is available for that. Instead, all produced energy goes directly back to the grid. This is because the system is small, plus the objective has not been to go off the grid. But if this were to be the case, space limitation would be a barrier to overcome. However, the grid connection acts as the storing technology for the produced electricity. It could be said that both storage and equilibrium management are currently outside the system boundaries of this ICES.

6.3 GOVERNANCE SUBSYSTEM

Governance can be defined as “the formal and informal mechanisms and processes that humans use to manage our social, political, and economic relationships with each other and the ecosphere” (Prugh y Renner 2014). Analytically, governance is a way of viewing the world of politics and government, with the State expressing collective interests. As a matter of structures governance is dismissive of hierarchy, although horizontalisation has to be confirmed by changes in legal and constitutional frameworks. As process, governance enhances interactions among structures; it is dynamic with regard to both configuration and objectives, and there is no clarity in who defines the objectives (Pierre y Peters 2000). Governance situation in SES is described by seven variables, as summarized in the following table.

Table 5: Variables Associate to the Governance System

Variables	Case study situation
GS1 Government organizations	Municipality of Haarlem, primarily facilitating finance.
GS2 Nongovernment organizations	Energy cooperative DE Ramplaan, foundation DE Ramplaan, Energy providers, DSO distribution system operators, tax company, insurance companies.
GS3 Network structure	Refers to interrelated groups. Actors in the internal network: Foundation DE Ramplaan, Energy cooperative DE Ramplaan, the members and community and the municipality. External network connections: Qurrent cooperative, DOEN foundation, energy network provider Alliander, and other NGOs such as HIER Opgewekt.
GS4 Property-rights systems	Defined by buying, and owning, solar power parts. Parts are privately financed but in some cases set on collective space.
GS5 Operational-choice rules	Simplified. After buying solar parts and signing contract with energy provider, cooperative members only have to pay their bill.
GS6 Collective-choice rules	Each member of Energy cooperative DE Ramplaan has an equal vote in decision making
GS7 Constitutional rules	Set by national government laws and policies. At local level, the contract between the members and the cooperative, and members with the energy provider is applicable.

GS1. Government organizations

"Government organization is a public institution that governs the society" (Bal 2015). In this case, the municipality of Haarlem is the main involved governmental organization. It wants to become carbon neutral by 2030, and so it has been very supportive of the DE Ramplaan initiatives (Jan Wattel 2016). It is relevant to mention the municipality can restrict certain developments in line with legislation if applicable. But in this case, Haarlem government has been referred to as the provider of financial means for developing the consultancy reports which outcome was the advent of the DE Ramplaan energy cooperative. Additionally Haarlem has a high interest and provided the foundations and cooperative with sufficient expertise, information and data that was available.

GS2. Non-governmental organizations

There are three main non-government organizations involved, for the ICES technical side at least. The cooperative DE Ramplaan is responsible for the formal set-up at local level, for acquiring household members who buy the solar power parts and agree to a contract with the energy provider Qurrent and grid operator Alliander.

Qurrent is a non-profit energy production cooperative. Its earning model evolved around a monthly fee paid by its customers. Qurrent started out as a project financed by the DOEN Foundation. It is a "nationwide energy cooperative through which customers become the owners of their energy supply", but the specifics services one can acquire are: energy provision, energy production, participation in renewable power generation elsewhere, and energy efficiency diagnosis (DOEN 2016).

Concerning energy transmission, the grid operating company or DSO in the Ramplaankwartier is Alliander. According to its 2015 Corporate Social Responsibility report, the most important subject for this company is energy transition; the second one is reliability of supply. Due to the energy landscape this company foresees, which includes grid defection and more renewables inclusion, its strategy is to facilitate bottom up energy initiatives along with developing the incentives and technologies to enable renewable energy grids manageability (Alliander 2016).

Besides Qurrent and Alliander, other stakeholders important for the Ramplaan case are the tax company, the insurance companies, and other NGOs such as HIER Opgewekt.

GS3. Network structure

The network structure in ICES refers to interrelated groups among the resource system. It can be confusing when applied to the energy sector, since here it would refer to the elements such as the grid, the generation technologies, etc. So, in this case we want to refer more to the actors. An example by Delgado and Ramos (Making Ostrom's framework applicable to characterise social ecological systems at the local level. 2015), for ecosystem services, considers social networks, community networks, environmental networks and market networks. For the Ramplaan case, we consider the network can be divided into internal and external stakeholders. Inside the neighbourhood, there are several interacting groups: the energy cooperative DE Ramplaan, the foundation, the municipality, the members, the facilitators such as the Fablo tennis court and smaller groups that have provided space for the foundation to hold meetings or events: the church and the school, for example. Both the foundation and the cooperative has been formally set-up and comply to all rules that follow their set-up. Therefore, the governance system is made as clear as possible, but because both are run by local inhabitants the each individual from the community can easily get engaged. Outside the neighbourhood, a governance role is played by: The government, the national energy cooperative Qurrent and Alliander, which provides the infrastructure for transmission and is developing business models that can accommodate more renewables and more decentralization initiatives.

GS4. Property-rights systems

Property right is defined by the “exclusive authority to determine how a resource is used” (Alchian 2008). For the case study, the properties concerned are solar power parts installed on either private roofs or a collective roof in the community’s tennis court Fablo. Property rights are private. Although the parts only function together, as party of the energy system, they are privately owned by members. The cooperative is financed by the municipality and the energy generated by the solar PVs is measured and depending on the share of solar power parts each member gets a discount on their private energy bill. (Wattel 2016)

GS5. Operational-choice rules

Operational rules define who, how, where, when, and why someone has access to the resource units (Delgado-Serrano y Ramos 2015). According to Bal (2015), these rules can change relatively rapidly, and they affect and are affected by the everyday resource problems. However, in the Ramplaan case, once the resource system was established and functioning, no more rules than paying the monthly electricity bill are applicable. The operational rules are set by the contracts with the cooperative and the energy provider Qurrent. This ICES is not dynamic in the operational sense because only one technology is installed and it is connected to grid under a fixed tariff. Decision making at community level is simplified because the energy and grid companies take care of the necessary operations and rules enforcement.

GS6. Collective-choice rules

Collective choice rules refer to rules set by involved actors in accordance to the local context, in terms of political, economic and environmental conditions. For the case study, no collective choice rules have been developed yet. As mentioned by the cooperative chairman Wattel, the idea in the beginning was to convince people to join under easy to adopt rules. This means that there was not much room for collective choice rules to be created; they were rather designed under the context of the Dutch energy market and available policies. They asked their member to join before there was clarity on the specific energy production, investment and payback period. By being a cooperative, the board set up statutes and ensured all the obligations a foundation has to comply with by law. When necessary, important decision making is done by the members of the cooperative, and each member has an equal vote, regardless of the investment made. (Wattel 2016) Now that a second wave of action will begin for foundation DE Ramplaan, members will have to make decisions regarding what will its next objective for the ICES will be.

GS7. Constitutional rules

Constitutional rules are those given by the legal framework of the country at any level (Delgado-Serrano y Ramos 2015). Concerning the energy sector in the Netherlands, it was only in 2004 that the energy market was liberalized. Historically, the country has been largely dependent on fossil fuels, but nowadays the laws and objectives are influenced by the European Union. Presently, it has been pointed as lagging behind for meeting the EU objectives on transitioning to renewable energy. The current target is to achieve 14% renewables in the energy mix by 2020, and 16% by 2023, but the long term outlook is unclear (Deloitte 2015). Concerning communities, they do not have obligation to produce energy, but they can do it and the current policies in the country promote it. In the Ramplaan case an example of a constitutional rule that improved the cooperative was the Postcoderoos policy which increases the pool of households that can become members.

GS8. Monitoring and sanctioning rules

This variable refers to processes locally adapted to monitor and, if applicable, sanction the resource use and the system's management strategies (Delgado-Serrano y Ramos 2015). The only monitoring practice conducted so far in the Ramplaan case is that of measuring energy production and consumption through energy meters. This information is available, but only measured at private level. Neither the foundation nor the cooperative have tried to find way to monitor why and to what extend members were engaged, how much the energy bill decreased and how measure the success of their arranged meetings and promotion activities. (S. Jansen 2016) As for sanctioning, Wattel (2016) stated that there had so far not been situation where such a rule was necessary, nor internally as within the community.

6.4 RESOURCE UNIT SUBSYSTEM

This subsystem describes the resource units generated by the resource system. Resource units can be countable, manageable or a measure by approximations (Delgado-Serrano y Ramos 2015). For the Ramplaan case, we defined the resource units as the energy units extracted from the PV panels. Concerning tangible matter, members of the Ramplaan cooperative buy solar power parts. These are the ones rendering the resource units: energy kWh from solar power. The following table briefly describes the variables comprising the subsystem under the SES framework.

Table 6: Variables associated with Resource Units

Variables	Case study situation
RU1 Resource unit mobility	Hardly mobile because installations are tailor suited for the community.
RU2 Growth or replacement rate	Dependent upon number of members and installations' life span, which is estimated at 20 years.
RU3 Interaction among resource units	Unrecognized yet, because of the system being connected to the grid.
RU4 Economic value	Yearly return in taxes to each member for producing renewable energy.
RU5 Number of units	Amount of produced energy: 400.000 kWh
RU6 Distinctive Characteristics	No distinction found. One resource is produced under the same circumstances.
RU7 Spatial and temporal distribution	Spatially restricted to the Ramplaan neighbourhood. Temporally dependent on weather patterns.

RU1 Resource unit mobility

Energy units are mobile the moment they are created. Specifically, electricity, as this is the one concerning the Ramplaan case, has to be consumed the moment it is generated because there are no storage technologies in the community. Electricity is naturally mobile, but it is not a tangible thing the users can take with them if they decide to leave the community. In order to take it, they have to take the whole set of infrastructure enabling its production. Thus, the resource units are hardly mobile since installations are tailor suited to the buildings and users in the community. However, Wattel says they facilitate that members can re-sell their solar power parts if they are moving out or somebody passes away. This does not increase resource units' mobility, but does bring versatility to the resource system in terms of membership, which surely is a positive quality that enhances membership to the cooperative.

RU2 Growth or replacement rate

This variable refers to estimations in regard to the life cycle of the resource unit (Delgado-Serrano y Ramos 2015). Here again, we have to refer to the tangible technologies, or the solar power parts owned by the members, because electricity (the resource) has no life cycle to follow. It is consumed the moment it is produced. Also, we believe growth and replacement rate should be considered separately because they are independent variables for this case, and possibly for any ICES.

Growth is dependent upon the number of members who decide to join the cooperative, and also upon the size of their investment since it affects the ability to place new technologies. One of the key limiting factors is available space in the neighbourhood. Space was a key issue even when each member could have installed the solar panels on their own roof (they were installed on the tennis court roof, which is collectively used). This was because of aesthetic reasons. In the Ramplaankwartier neighbourhood, people value the architecture of their house and is hardly willing to make it "ugly" (S. Jansen 2016).

On the other hand, the replacement rate of technologies depends on their respective life span. In this case, the payback period is between 10 and 15 years, so the lifespan should be larger than that. For now, the collective roof usage has a contract lasting twenty years. After 20 years the value of the solar power parts has decreased significantly and the project will be discarded, but the production will probably still keep running. (RVO 2016) Also, depending on the future of the cooperative, there are possibilities of renewal or implementation of new technologies before that date. (Wattel 2016) This is different from what happens in the case of natural resources exploitation where renewability can be taken as given, indefinitely, if proper management is ensured. At this moment, it is totally up to the cooperative members to maintain the resource system or not.

RU3. Interaction among resource units

This variable refers to those characteristics of the resource units that are complementary or that compete; it is about pattern relationship identification (Delgado-Serrano y Ramos 2015). Since at the moment there is only one resource unit implemented (energy from solar panels) in the Ramplaankwartier, there are no applicable interactions. Besides, even if there were other technologies installed, since the system is connected to the grid, the users would not get to manage interactions among them because the distribution company does it for them.

RU4. Economic value

Delgado & Ramos (2015) propose this variable not as economic value, but as resource value. They describe it as "the value of the resources, including the values non recognized by the market". On the one side, value refers to the monetary worth of the resource; on the other it something like a principle or a quality that is valuable or desirable, something positive. We believe it is clearer to analyse these two types separately, that this differentiation is also appropriate for this ICES case.

The business model in the Ramplaan case is simple. It was designed to facilitate members entrance (Jan Wattel 2016): community members could sign up by buying solar power parts. Each part was equal to 225 kWh per year. (RVO 2016) The needed investment per part was €325. And the payback period is ten to fifteen years.

Besides that, a contract with energy company Qurrent was required. Each member is required to at least buy 2 solar power parts. So in short, each member needs to invest at least €700 to be able to join. By paying this they have financed solar power equal to 225 kWh per part annually. The produced energy is put back into the grid, but recorded by Qurrent. Depending on the amount of parts financed the household will get a discount on their energy bill at the end of each year. Thus, the resources unit's economic value is that of decrease in the energy bill in the form of cost savings, which will be on-going for as long as the project is operating. When most of the members subscribes the payback period was still unknown, but it later turned out to be between 10-15 years. According to Wattel (2016) the main reason for people to join was not the business potential but because on an interest in sustainability, a community feeling and the easy this set-up made people be more sustainable.

The non-economic value of the Ramplaan ICES cannot be measured at this stage, but it can be recognised by talking to members of the cooperative. They speak of: awareness rising, the volunteer work done to run the cooperative and of growing social cohesion among members. The cooperative chairman mentions the reasons for members to join were sustainability concerns, community feeling, and the simplicity.

RU5. Number of units

In the resource system, the size was defined by capacity. Concerning the resource unit subsystem, the number of units equals the amount of energy produced and sent to the grid. In the Ramplaan, the members of the energy cooperative produce about 400.000 kWh on a yearly basis.

RU6 Distinctive characteristics

Concerning electricity, a distinctive characteristic is the primary source of energy and the technology used to extract it. In the Ramplaan case, all energy comes from one type of solar photovoltaic system with the same productivity and cost. Solar panels only function at its maximal on sunny days where the temperature is not too hot. Important characteristics of solar energy are that is it difficult to predict their quantifiable energy production and that there is no stable production due to weather conditions. The characteristics are similar if no conditions change, but with a growth of the technology, an improvement of solar PV or additions of new technologies these characteristics are open for change. Therefore, it is difficult for an ICES to only rely on one type of renewable energy like solar PV. This variable would be more relevant to describe if there were several technologies within the ICES, and also if there were more than one type of resource besides electricity (e.g. heat and fuels). Each resource would be distinct based on the natural resource it exploits, and the temporal availability that governs it.

RU7. Spatial and temporal distribution

The spatial distribution is defined by the joining members within the community. With the addition of the Postcoderoos the members are not only restricted to the Ramplaankwartier neighbourhood, but can also join if they have similar postal codes. Because the current system is set-up that almost all solar PVs are located on the roof of the same tennis court, there is no spatial distribution for the resource unit. The connection of the PVs to the members is a contractual arrangement rather than a physical one. The temporal distribution depends on daily weather patterns concerning radiation. However, the characteristics of the technologies can change allowing for more production.

6.5 ACTORS SUBSYSTEM

Actors refer to direct participants in the resource system (McGinnis y Ostrom 2014). This subsystem describes those actors who affect or are affected by the resource system (Delgado-Serrano y Ramos 2015). In the case of the Ramplaan there are most of the actors are deliberate participant and are thus emotionally involved as well. This can make the actors' network different from a SES. Ostrom suggests nine variables for describing this subsystem, as shown in the following table.

Table 7: Actors of the Subsystem

Variables	Case study situation
A1 Number of relevant actors	Six main groups are identified: cooperative members, foundation, non-members living in the neighbourhood, municipality, energy company and DSO.
A2 Socioeconomic attributes	Home owners, upper class, middle age, proud of their neighbourhood.
A3 History or past experiences	No past experiences.
A4 Location	Ramplaankwartier, Haarlem
A5 Leadership/ entrepreneurship	Mainly practiced by the energy cooperative DE Ramplaan board
A6 Norms (trust-reciprocity)/ social capital	Social capital built through communication. Social norms are unknown for outsiders.
A7 Knowledge of SES/ mental models	Knowledge framed in signed contracts. Renewable energy is desirable, but do not want to deal with developments that require additional effort.
A8 Importance of resource (dependence)	Not important since the system is not decentralized. Improvement depends on willingness to adopt change that is only desirable but not mandatory.
A9 Technologies available	Solar PV. Availability is restricted by individual financial capital to join the project.

A1 Number of relevant actors.

For the Ramplaan case, the most important actors identified are the energy cooperative, the foundation and the prosumers, being the members. The cooperative board committee is very relevant, since they lead the ICES. They were initiated and are monitored by the Ramplaan foundation, but are responsible for the whole set-up system. In total there are 220 members; five of them are commissioners of the board. The Foundation DE Ramplaan, comprised of 11 persons, manages studies and projects for advancing the ICES. The next important actors is the facilitator of the area for the solar PVs, the Fablo tennis court. In fourth place, there are the citizens who live in the neighbourhood, including those who have not joined the cooperative. The latter are important to consider because they can be affected by the ICES and their opinion might have to be considered at some point if new projects arise. Outside the neighbourhood, the Haarlem municipality is an important actor supporting, also financially, either the cooperative or the foundation´s projects for advancing the ICES. Last but not least, the energy company and the DSO are important because they greatly shape the business model under which the ICES operates and are essential in enabling the energy transportation. In short, the number of relevant group of actors is six:

1. Energy cooperative DE Ramplaan: board members and other members (prosumers);
2. Foundation DE Ramplaan;
3. Fablo tennis court;
4. Citizens who are not members of the energy cooperative and live in the neighbourhood;
5. Haarlem municipality;
6. Energy company: Qurrent;
7. Distribution System Operator: Alliander.

Next to those 7 main actors, Wattel also mentioned that other actors include the tax company, insurance companies, other NGO's that work on similar initiatives and the national government.

A2 Socio-economic attributes

Tulip production is the main industry in Haarlem. The place is considered as a bedroom community, as due to its closeness to Amsterdam, many of its inhabitants work in the latter city. The inhabitants are in general well to do, as the average personal income as of 2013 was 32,000 which is higher than the average Dutch (CBL 2016) (Elsinga, et al. 2007). The Ramplaan neighbourhood is somehow special. They consider themselves living in a sort of green island because the neighbourhood is a clear enclosed group of houses that separates themselves from the city and other nearby living areas. The community is described as being mainly comprised of middle age, middle to upper class, white families. The neighbourhood holds about 1000 homes, out of which about 10% are members of the cooperative. The other members of the Ramplaan foundation come from nearby areas that fall within the Postcoderoos policy. Concerning detailed information on the members, there are no formal records on the topic. People know each other because they are neighbours, and have been for some time, but this information is unavailable for non-community members.

A3 History or past experiences

The history of past experiences in SES is defined as the "chronological description of the main events related to the resources and its management" (Delgado-Serrano y Ramos 2015); it is about describing the way a community previously benefited from the resource, before becoming what it currently is. For the Ramplaan neighbourhood there is no past experience producing and selling energy as a group. The recent history of the Ramplaan consists of an established infrastructure, with already existing houses connected to the regular grid. As for community work, the interviewed community members did not mention any example of the sort. They have shared facilities, like the tennis court; and the foundation organizes events at the school and elderly home to promote their work, but no working together experience was identified. However, the foundation is keen on starting cooperatives to remove governmental limitations on private energy production.

A4 Location

This variable refers to the" geographical location of the resource system users" (Delgado-Serrano y Ramos 2015). This is simply the Ramplaankwartier neighbourhood. Currently, the system´s infrastructure is mainly concentrated on the tennis court collective roof.

Figure 14: Ramplaankwartier

A5 Leadership/ entrepreneurship

This variable refers to the identification of attitudes toward leadership and entrepreneurship among the actors (Delgado-Serrano y Ramos 2015). Leadership refers to the individual or organization with vision, who leads the resource improvement; while entrepreneurship refers to engaging in resource improvement activities for commercial purposes (McGinnis, 2010). In the Ramplaan case, the board members of the energy cooperative play both the leading and entrepreneurial roles. Each member has an own expertise, and they have put effort into having a good combination: communication, financial and technical. In the beginning of the project, in 2011, when the foundation was created, the person who initiated awareness creation and was very enthusiastic was referred to as very important, as the visionary who wanted to make the Ramplaan area sustainable. Later on, implementers came into action and the business model took form in 2014. This was also the start of the cooperative. During the interviews, the cooperative chairman stated that it used to take the members of the board six to eight hours a week to carry all the needed activities to advance the ICES case in the beginning; now it takes them about one. All work is voluntary. It is relevant to mention that the entrepreneurial part focused on achieving a feasible cost for the solar panels, but it has never been the intention to make money from the ICES (Wattel 2016)

A6 Norms / social capital

This variable should describe the levels of social and institutional interactions among the actors. It should consider reciprocity and trust (Delgado-Serrano y Ramos 2015). This is a difficult variable to measure for an outsider. When asked about forms of communication and decision making among the members of the community, the interviewed actors responded its easy because they all know each other since they are neighbours and are culturally very similar. It is complicated to determine the local norms and the level of social capital without experiencing the community. So far we learned that the foundation and the cooperative tried to reach out to their neighbours through meetings in the old church; they got people to sign up their email address and communication started flowing. Nowadays the cooperative sends a newsletter every 6-7 weeks. The chairman referred that even when they don't have significant internal conflicts, there is a lot of communication and trust necessary (Wattel 2016). Since the changes in people's lives would be minor and the ideas were not very controversial, members were willing to invest with no opposition.

A7 Knowledge of SES/ mental models

This variable has been defined as the one describing the "community awareness about the resource, its scarcity and management" (Bal 2015), and the level of knowledge about the system's conditions and disturbance patterns (Delgado-Serrano y Ramos 2015). In the Ramplaan case, the general mental model is that renewable energy is desirable. But while some members think decentralization is going to be more common in the future, others doubt if that is the best way to go. While Sabine Jansen (2016) and Merian Koekkoek (2016) are uncertain that going off grid is desirable for the future because we have such a reliable centralized system that improves efficiency, Eise Jan Wattel is expecting the opposite. He sees a future in the decentralization of electricity systems. Either way, we do have to start thinking more regionally and collaborate with actors to get properly aligned. (Koekkoek 2016)

Concerning knowledge on the system, it is based on the signed contracts. Members know they have financed for a certain part of the produced energy which is managed by Qurrent. They know they have to pay for the solar parts acquired, and that they have a say when it comes to decision making concerning the ICES. At the moment, the system is stable and the energy cooperative board is not actively looking for new members, but there is the idea of expanding the system to get more solar panels on other collective roofs such as the library. (Wattel 2016) However, a new wave of activity is expected with the development of a new project for the area for which the foundation is collaborating with researchers from Delft university. It is acknowledged that doing more complex projects could bring co-benefits to the Ramplaan neighbourhood, but implementation is not easy since most people are busy and do not want to deal with developments that require additional effort (S. Jansen 2016).

A8 Importance of resource (dependence)

This variable describes the "user's dependence on resources for livelihood" (Delgado-Serrano y Ramos 2015). In the Ramplaan case, the members do not depend on the energy they generate because their system is not decentralized. Producing the resource is not crucial. The amount of effort put to improve their ICES, enlarge their energy production or decrease their community footprint is solely up to their willingness to advance non-mandatory change.

A9 Technologies available

This variable describes the "types of technologies used to extract, harvest and manage the resource, and access of users to different technologies" (Delgado-Serrano y Ramos 2015). In the Ramplaan, the only technology used is solar PV. Access is limited to those having a contract with the energy cooperative and the energy company Qurrent. Availability is open to all those who decide to join the cooperative and buy solar power parts, given they are residents of the right postal codes. Concerning future developments, the availability of technologies is restricted by individual financial capital and the willing to join the project. With enough capital, all existing technologies suitable to the area could be available to all potential prosumers in the community (granted the right permits and infrastructure are in place).

6.6 INTERACTIONS SUBSYSTEM

The interactions subsystem describes the influence the resource units, resource system, governance system, and actors, have on each other. Later, these interactions result in outcomes. (Delgado-Serrano y Ramos 2015). The following table summarizes the interactions between subsystems in the Ramplaan case.

Table 8: Variables associated with Interactions

Variables	Case study situation
I1 Harvesting	On average, 225kWh per year per solar power part. (RVO 2016)
I2 Information sharing	Mouth to mouth and by periodic newsletter.
I3 Deliberation processes	Energy cooperative board deals with communication with external actors and day to day decisions. Important choices consider all the cooperative members.
I4 Conflicts	No significant conflicts due to effective communication and trust among members.
I5 Investment activities	One investment so far: €450.000. No new investment being made at the moment.
I6 Lobbying activities	One so far, related to postcode roos. Now the community has the largest number in the country.
I7 Self-organizing activities	Done for investing purposes, but not for resource management.
I8 Networking activities	Active networking with actors outside the system: university, government, other cooperatives and NGOs.
I9 Monitoring activities	Energy production can be monitored, but this is not done as a group activity targeting the ICES' improvement.
I10 Evaluative activities	Inexistent so far.

I1 Harvesting

This variable is defined as the quantity of harvested resources by the different actors (Delgado-Serrano y Ramos 2015). On average, the members of the energy cooperative in the Ramplaan neighbourhood own 7.3 solar power parts, with a nominal power of 370 kWp, which in terms of energy production are estimated to 400.000 kWh per year (RVO 2016)

I2 Information Sharing

This variable discusses the various ways in which information is shared between actors. For the Ramplaan case, information was said to be communicated mouth to mouth, since as neighbours they know and talk to each other (S. Jansen 2016). Additional to these encounters the cooperative provided potential members with flyers and an occasional email with extra information. Also, the cooperative makes a newsletter every six to seven weeks which is delivered by mail (Jan Wattel 2016). Other information sharing sources were external communication with the press, home-to-home flyers, prospectus on the website and a personal letter from the alderman to all the Ramplaankwartier inhabitants. (RVO 2016)

I3 Deliberation processes

Deliberation processes refer to discussions & consultation between actors involved and the governing agents. Deliberation can also occur between actors in the system and actors outside of that system. In the Ramplaan case, the energy cooperative board has been dealing with these kinds of processes: discussions with the municipality, energy provider, tax company and insurance companies. They have set up statutes and function in accordance with all the legal responsibilities a foundation has to comply with. Decision making on important choices, such as the future of the cooperative or the desired tax reductions, was said to include all of the cooperative members, each one having an equal vote.

I4 Conflicts among users

More than conflicts, among the barriers faced by ICES's members in the Netherlands is the fact that most energy cooperatives exist voluntarily because of the persons who decide to donate their spare time. Often, a working structure for the organization is missing and volunteers might lack the necessary qualifications to deal with the work in a more efficient way (Koekkoek 2016). This does not create conflict in the system, but can prolong the time for conflict resolution. The Ramplaan ICES faces a similar situation. One of the conflicts they overcame to install the solar panels was the decision on where to locate them. People were willing to invest in the technology, but they didn´t want it on their own roof because of the distortion of the aesthetics, and this is why the collective roof was the solution. One of the barriers the energy cooperative mentioned was getting all parties aligned, which was handled through communication and trust building. Up until now there were no significant internal conflicts in the Ramplaan case (Wattel 2016).

I5 Investment Activities

This variable refers to investments for improving and managing the resources. It considers information such as investor, amount invested and destination of investment (Delgado-Serrano y Ramos 2015). For the Ramplaan case the investors are the municipality and the members of the energy cooperative. The investment takes the form of solar power parts, each with a value of €325. Currently, there are no more investments being made. The total investment of €450.000 was financed for 100% by the members of the cooperative. The investment of the municipality was used for pre-financing the project. The municipality produced the high level business case and invested in professional help to calculate the strength of the tennis court roof. In the very early phase the Rabobank financed the foundations several thousand euros from their sustainability fund to cover the costs for the space rent and the paperwork. (RVO 2016)

I6 Lobbying activities

This variable considers internal and external influence capacity of the actors (Delgado-Serrano y Ramos 2015). The board of members take care of these activities. In the Ramplaan energy cooperative so far, one lobby activity was referred to during the interviews. This was concerning the earlier described Postcoderoos policy. The agreement the policy presented was not feasible enough so due a collaboration with other parties the Foundation and cooperative managed to improve the agreements to get the policy to be financially interesting.

I7 Self-organising activities

Self-organizing activities are the internal rules for the extraction and management of resources among the actors (Delgado-Serrano y Ramos 2015). In the Ramplaan case such rules are given by the contracts the members sign with the energy cooperative and the energy company. In strict terms, the members do not manage the resource but leave the management to a third party: Qurrent. They contribute to the Qurrent's business model by providing it with renewable energy and securing their energy needs. Thus, self-organization is done for investing purposes, but not for resource management.

I8 Networking activities

This variable describes the activities for exchange of information and services among actors within and outside the community (Delgado-Serrano y Ramos 2015). Here, in the Ramplaan case, networking is done by both the energy cooperative and the foundation. They maintain contact with other energy cooperatives and NGO such as HIER Opgewekt. Also, they are in close relation with the municipality, which has been very supportive of their attempts to build the ICES. And the Foundation is currently working with Delft University to develop a new plan for the neighbourhood. All the networking eventually renders in advancing the system. Currently, the energy cooperative chairman foresees the possibility of merging their ICES with other cooperative in Haarlem, setting in place a communication plan for a project concerning insulation, and even considering the possibility of selling the cooperative to a bigger actor in Haarlem: Kennemer Energy. (Wattel 2016)

I9 Monitoring activities

Monitoring activities deal with keeping track on "the use and management of resources and their performance" (Delgado-Serrano y Ramos 2015). In the Ramplaan case, members can monitor energy production, but they do not do it in an organized way, as a group that would use the information to improve their system. Only Qurrent has data on the energy production and the usage of the members. Neither the foundation nor the cooperative has any other monitoring activities to evaluate on the progress. (Wattel 2016)

I10 Evaluative activities

This variable has been defined as the processes of evaluation of the resource situation and of the effects of management activities (Delgado-Serrano y Ramos 2015). So far this sort of activities has been absent in the Ramplaan case. Neither the impact of the foundation nor that of the cooperative has been researched yet. According to Wattel (2016), after stabilizing the activities of the cooperative there will be opportunity to talk about the future of the cooperative and the sustainability of the Ramplaankwartier.

6.7 OUTCOMES SUBSYSTEM

The outcomes subsystem describes the results of the interactions among the previously described variables. "It explains and evaluates the results of the dynamic interaction processes among different subsystems and the interrelations and influences on the SES" (Delgado-Serrano y Ramos 2015). The framework proposes three variables to describe outcomes. The Ramplaan case status is summarized in the following table.

Table 9: Variables associated with Outcomes

Variables	Case study situation
O1 Social performance measures (e.g. efficiency, equity, accountability, sustainability)	Adequate. Allow members participation and system improvement if desired.
O2 Ecological performance measures (e.g. overharvested, resilience, biodiversity, sustainability)	Positive outcomes, but not strategically targeted.
O3 Externalities to other SESs	Unexplored by the members or their leaders.

O1 Social performance measures

This variable includes social and economic process. It describes the evolution and impacts of efficiency, equity, accountability and sustainability. For the Ramplaan case, this is a difficult variable to evaluate. All that the cooperative has done so far to harvest renewable energy has been in the frame of a contract with the energy company. Efficiency has not been measured, and there is no base for comparison within the community. Equity is targeted by giving equal vote to each member of the cooperative disregarding the number of power parts owned. Accountability is attained by the statutes the cooperative board makes sure to implement, and periodically a newsletter is sent to all members. The board of the cooperative is controlled by the foundation, but up to this point the enthusiasm of the board did not suffer from any malfunctioning according to Wattel

(2016) Concerning sustainability, the ICES, in the form of the cooperative with one technology implemented, has been sustained for two years already (since 2014). To decide on the future of the cooperative some members are proposing to sell it to a bigger one. Wattel (2016) explained how selling the cooperative could give the sustainability of Haarlem a boost and expand the project to more technologies. Also, by bringing together multiple stakeholder and multiple project a better foundation for local renewable energy supply or an off-grid system can be developed. (Koekkoek 2016) In general, social performance is adequate, allowing members' participation and system improvement if desired.

O2 Ecological performance measures

The ecological performance measures variable describes the evolution and impacts of ecological concepts (Delgado-Serrano y Ramos 2015). When considering renewable energy is the produced resource, the main ecological expected performance is the reduction of carbon dioxide emissions. However, this variable has not been estimated for the Ramplaan case. The case obviously has an impact over the greenhouse gas emissions generated due to energy production in the region, but the information has not been used to determine goals or advance the ICES. The project van initiated from the sustainability aims of Haarlem, but for the cooperative the main incentive was to increase green energy production and get the community involved. (S. Jansen 2016) Overharvesting do not make much sense as third level variables for an energy system. Biodiversity can be important depending on the type of technologies used, but for the Ramplaan case, it is not a relevant variable. Resilience is important, but so far it hasn´t been consider as part of the system´s targeted objectives.

O3 Externalities to other SES cases

Externalities refer to non-desired effects, either positive or negative, that result from processes implementation (Delgado-Serrano y Ramos 2015). In this case, although it was not referred during the interviews, the foreseen negative effect of the Ramplaan ICES is the increase in prices for non-renewable energy prosumers in the region. However, there were still little signs of other externalities due to the relative small size of the project and the effect on the members. Since the project is only now reaching a steady state, possible externalities, if any, are likely to appear at a later stage or when the cooperative is joined with other initiatives.

6.8 RELATED ECOSYSTEMS SYSTEM

This last system is about connections the previously described systems and subsystems with the surrounding environment. It considers the system influence on climate patterns, pollution patterns and flows into and out of the resource system. The following table summarizes the situation in the Ramplaan neighbourhood.

Table 10: Variables associated with Ecosystems

Variables	Case study situation
ECO1 Climate patterns	Influence is small but important. GHG emissions reductions have not been computed.
ECO2 Pollution patterns	Small influence with non-perceptible changes.
ECO3 Flows into and out of focal SES	Increased flows to the resource system, but diminished abiotic resources extraction from the ecosystem.

ECO1 Climate patterns

Climate patterns are difficult to influence, as they are created based on long term changes in the climate system. The Ramplaan ICES on its own cannot make a difference on them, but it certainly does contribute to advance renewable energy adoption inside the neighbourhood, and the Netherlands. For promoting the adoption of renewables, which contribute to climate change mitigation and adaptation, we consider the ICES to be important. Its GHG emissions reductions have not been computed so far, but such initiatives do not only improve renewable energy use, they also improve citizen engagement which is essential for the total energy transition. Already in the Ramplaankwartier area there were more people willing to join then initially expected.

ECO2 Pollution patterns

Pollution patterns are influenced by renewable energy adoption; they would usually be diminished if compared to fossil fuels combustion alternatives. By installing photovoltaic solar power generation, the Ramplaan ICES is not altering their local pollution patterns. As their consumption of energy is small when compared with national requirements it is hard to believe this ICES alone influence pollution patterns. But again, the project is very important for advancing renewables adoption in the country and thus generate perceptible changes in the ecosystem system.

ECO 3 Flows into and out of focal SES

By implementing the ICES incoming flows of materials increased for the resource system, for technologies manufacture and installation in the community. But ultimately this can represent a decrease in abiotic resources extraction, or outflows, somewhere else. Again, the impact of the community is not perceptible, and has not been studied yet.

7 CONTRIBUTING TO FACILITING ICES

After analysing the Ramplaan case using the SES framework, most variables appeared to be useful for understanding the processes that took place at different stages of its implementation. We believe the variables would have been useful to create a structured methodology for facilitating this ICES and advance it quicker. This chapter describes our proposal for a modified framework and method to facilitate the Ramplaan ICES in retrospect, if it were to start all over again. This way, we also answer our research question by showing that the SES framework, with some modifications, could have been applicable to a great extent to advance the process of the Ramplaan more efficiently.

The chapter is divided into three sections. First, we present our modified SES framework based on the Ramplaan case analysis in chapter 5 and 6. Secondly, we propose a facilitation method that could be used if the Ramplaan case were to begin again. Here, we use all of the variables from the proposed modified framework, and then select the most important ones to link them to topics from the industrial ecology field which can be used as tools to enhance the method performance of the variable. Thirdly we describe why this method is not justified to be a general one for implementing ICES, but we speculate which parts could be generalizable and thus, set the basis for designing an agent-based model (chapter 7).

7.1 MODIFIED SES FRAMEWORK: ADAPTATION FOR THE RAMPLAAN CASE

The SES framework is a constantly changing framework of IAD framework principles. The action situation, which is the core of the IAD is represented by the variables of the interactions and outcomes systems in the SES. But the SES components need to be identified for each particular application because the framework is intended to be general, so that it can be used by any type of social-ecological interaction. (M. D. McGinnis, Updated guide to IAD and the language of the Ostrom workshop: a simplified overview of a complex framework for the Analysis of Institutions and their development 2016) In this section we introduce a modified version of the SES framework, applicable to the Ramplaan case, and elaborate on each modification.

The analysis in Chapter 5 and 6 gave insights on how each variable is applicable to the Ramplaan case, approached as an ICES. Although all variables are briefly discussed, not all variables seem relevant for an ICES, more specifically the Ramplaan case. To make the framework specific to the Ramplaan ICES, the first step was to decide on which variables were redundant or not applicable. For some variables it felt necessary to alter the name or relocate it from one variable group to the other. The following section tries to justify all the modifications and then presents the proposed modified version of the framework.

7.1.1 VARIABLE OUTTAKES

Before elaborating on the variables that were either taken out or were changed somehow, it must be stated that removing a variable is not considered as a modification to the framework. In many SES analyses it occurs that variables are irrelevant and therefore ignored. Therefore, these removals are not considered part of the actual modifications, but should be stated nonetheless for they are disregarded in the new framework. In total, nine variables were taken out from the original SES framework. Three of those variables belonged in the group of the social, economic and political settings system. All of them are marked in the colour blue in the following Figure showing the original framework.

Table 11. Taken out variables from the modified SES framework

Social, economic, and political settings (S)	
S1 Economic development, **S2** Demographic trends, **S3** Political stability, **S4** Other governance systems, **S5** Markets, **S6** Media organization, **S7** Technology.	
Resource systems (RS)	**Governance system (GS)**
RS1 Sector (e.g., water, forest, pasture, fish); **RS2** Clarity of system boundaries; **RS3** Size of resource system; **RS4** Human-constructed facilities; **RS5** Productivity of system; **RS6** Equilibrium properties; **RS7** Predictability of system dynamics; **RS8** Storage characteristics; **RS9** Location	**GS1** Government organizations; **GS2** Non-government organizations; **GS3** Network structure; **GS4** Property-rights systems; **GS5** Operational-choice rules; **GS6** Collective-choice rules; **GS7** Constitutional rules; **GS8** Monitoring and sanctioning rules
Resource units (RU)	**Actors (A)**
RU1 Resource unit mobility; **RU2** Growth or replacement rate; **RU3** Interaction among resource units; **RU4** Economic value; **RU5** Number of units; **RU6** Distinctive characteristics; **RU7** Spatial and temporal distribution	**A1** Number of relevant actors; **A2** Socioeconomic attributes; **A3** History or past experiences; **A4** Location; **A5** Leadership/entrepreneurship; **A6** Norms (trust-reciprocity)/ social capital; **A7** Knowledge of SES/ mental models; **A8** Importance of resource (dependence); **A9** Technologies available
Action situations: Interactions (I) -> Outcomes (O)	
I1 Harvesting; **I2** Information sharing; **I3** Deliberation processes; **I4** Conflicts; **I5** Investment activities; **I6** Lobbying activities; **I7** Self-organizing activities; **I8** Networking activities; **I9** Monitoring activities; **I10** Evaluative activities	**O1** Social performance measures; **O2** Ecological performance measures; **O3** Externalities to other SESs
Related ecosystems (ECO)	
ECO1 Climate patterns, **ECO2** Pollution patterns, **ECO3** Flows into and out of focal SES	

The justification for eliminating each variable is the following:

- *Demographic trends* was left out because it can be covered in the actor subsystem. For an ICES development, description of population trends outside the community is considered unimportant. Although it is relevant to know the demographics, since each ICES is a man-made system, it is can be adjusted to the needs of each location or community. It is therefore less important to know the specifications of the demographic trends, but more important to analyse its effects in the actor variable group. Therefore, this variable is seen as redundant and left out.
- *Media organization* was left out because, since free media is the business as usual in the Netherlands, there are no barriers to communication as in other countries. But also, most communication in the

Ramplaan case took place at very local level, within the community members. It is important to make use of media to develop and promote the project, but there were no restrictions to media usage for the Ramplaan project and nor will there be any in other parts of the Netherlands. Since there are no contextual demands or limitation to what can be published or spoken, this variable is insignificant. Media can be used and organized as desired and, thus, has little operational boundaries for the foundation or cooperative.

- The variable *other governance systems* was considered not to be necessary for the case because the accepted governance system in modern communities, as the Ramplaan neighbourhood, is the nationally adopted governance system. There are not governance structures in opposition to the current democratic landscape at national level. In the Netherlands we are constricted to the existing governance entities such as the national government, province councils and the municipalities that guide policies. For smaller projects like the Ramplaan case, the foundation and cooperative were set up, which are both directly included in the governance. Besides all these, there are no other bodies that have direct influence on the governance of the Ramplaan case that should be considered at this point. There are indeed other actors, but these are mentioned in the actor variable group.
- Both the variables *market incentive* and *technology* (underlined in Table 11) have not been removed but have become part of a new variable called *energy system,* which will be elaborated upon in the section 7.1.3

Besides the removed variables from the social, economic and political settings system, six more from other systems were considered redundant and were also out taken:

- For the resource system variable group, it seemed redundant to include the *sector* variable, since within an ICES we are always talking about the energy sector. Although the context of the ICES within the sector is key for the project development, we considered it would already be described as part of the *energy system* variable in the social, economic and political setting system. Therefore, for the resource system this variable is too obvious and does not add value to the framework.
- Following the same line of thinking, the *number of units* from the resource unit variable group is equally obvious and can already be covered by the variable *size*. The only resource unit for the Ramplaan ICES is the produced energy in the form on electricity. Since this is already clear from the resource system and the project belonging in the energy sector, there is no need to elaborate on the electricity furthermore. This variable is therefore removed as it is unnecessary.
- Also, the variable *distinctive characteristics* from the resource unit was omitted since we believe the information it brings can already be covered with the variable *interaction among resource units*.
- For the actor variable group, the *history of past experienc*e is removed. There are two reasons for this decision. First of all, the development of an ICES is very new and there is a very limited amount of previous cases available. Although platforms such as HIER Opgewekt share knowledge amongst current practitioners of energy cooperatives, the development of the first extended ICESs is still limited. Secondly, because each ICES is different because its tailor suited to the community, the experience each actor might have on the topic can already be covered by the existent mental models within the community. Which is a variable under the actor system.
- Also in the actor subsystem, the variable *location* is omitted since it was considered rather obvious. It might be of importance for large ICES, but for a case like the Ramplaan we believe it brings no relevant information to the analysis.

7.1.2 VARIABLE CHANGES

With several variables having been removed from the framework, the modifications of the framework need to be discussed. In total there were ten modifications in six different variable groups. They are all marked in orange colour in table 12, which shows the original framework. Colour blue signals out taken variables (as seen in Table 12), while colour orange signals the ones that's were somehow modified.

Table 12. Out takes and modifications to the SES original framework.

Social, economic, and political settings (S)	
S1 Economic development, **S2** Demographic trends, **S3** Political stability, **S4** Other governance systems, **S5** Markets, **S6** Media organization, **S7** Technology, **S8** Energy system: markets & technology	
Resource systems (RS)	**Governance system (GS)**
RS1 Sector (e.g., water, forest, pasture, fish); **RS2** Clarity of system boundaries; **RS3** Size of resource system; **RS4** Human-constructed facilities; **RS5** Productivity of system; **RS6** Equilibrium properties; **RS7** Predictability of system dynamics; **RS8** Storage characteristics; **RS9** Location	**GS1** Government organizations; **GS2** Non-government organizations; **GS3** Network structure; **GS4** Property-rights systems; **GS5** Operational-choice rules; **GS6** Collective-choice rules; **GS7** Constitutional rules; **GS8** Monitoring and sanctioning rules
Resource units (RU)	**Actors (A)**
RU1 Resource unit mobility; **RU2** Growth or replacement rate; **RU3** Interaction among resource units; **RU4** Economic value; **RU5** Number of units; **RU6** Distinctive characteristics; **RU7** Spatial and temporal distribution	**A1** Number of relevant actors; **A2** Socioeconomic attributes; **A3** History or past experiences; **A4** Location; **A5** Leadership/entrepreneurship; **A6** Norms (trust-reciprocity)/ social capital; **A7** Knowledge of SES/ mental models; **A8** Importance of resource (dependence); **A9** Technologies available
Action situations: Interactions (I) -> Outcomes (O)	
I1 Harvesting; **I2** Information sharing; **I3** Deliberation processes; **I4** Conflicts; **I5** Investment activities; **I6** Lobbying activities; **I7** Self-organizing activities; **I8** Networking activities; **I9** Monitoring activities; **I10** Evaluative activities	**O1** Social performance measures; **O2** Ecological performance measures; **O3** Economic performance measures; **O4** Externalities
Related ecosystems (ECO)	
ECO1 Climate patterns, **ECO2** Pollution patterns, **ECO3** Flows into and out of focal SES	

As described above, the *market incentive* and *technology* variables are now part of the variable *energy system* because it makes more sense to consider them as third level variables described under the general energy system context of the Netherlands (in this case). The legislation and economic incentives concerning each available technology in the country would be described under this variable applicable either regionally or at national level. The description of energy providers and transmission companies in general terms would be included as part of the market.

Within the resource system and the resource unit subsystem, the following modifications were made:

- *Size of resource system* was renamed to *size or capacity* to acknowledge the fact that energy systems are measured in terms of technologies capacity.
- *Human constructed facilities* was changed into *naturally-occurring facilities*. This is because in the original SES framework the variable described the facilities created by humans which could influence the ecological system. However, in an ICES everything is human constructed and therefore, the variable would be redundant. But since within renewable energy technologies, we are dependent on the availability of naturally occurring energy resources it seems of added value to consider the *naturally-occurring facilities*. These naturally occurring facilities depend on the location of the ICES and have to be accounted for during decision-making between multiple technologies and their location.
- *Resource unit mobility* and *Growth and replacement rate* variables were moved from the resource unit system to the resource system. Since the resource unit is electricity and the mobility of electricity production as a unit is irrelevant, it is more suitable to look at mobility and the replacement rate through a systems perspective, considering the tangible technology as the one with the availability to be moved, enlarged and replaced. The mobility of electricity is untraceable and therefore irrelevant to look at. It is more interesting to look at the mobility of the technology and the possibilities of the infrastructure together with the replacement necessity of the technologies involved.
- *Predictability of system's dynamics* was moved from the resource system to the resource unit subsystem. We see the resource systems as the one describing the technology in use, while the resource unit subsystem as the one describing the energy produced by the technology (by the resource system). Since technology is the static mechanism for production, if natural resources are available, technology will simply function. In this regard, it makes more sense to predict energy than technology availability.

Concerning the governance system and actor subsystem, the following changes were made.

- Non-government organizations were proposed to have two third level variables: internal and external organizations. This, because each type of organization required a different view at it and should be separately analysed.
- *Network structure* was renamed as *Social network structure* (the social element was added). Since we are talking about a socio-technical system the network might suggest that we are talking about the infrastructure. However, this variable is aimed at the governance and the actors involved and is therefore renamed.
- *Monitoring and sanctioning rules* was changed into only *monitoring rules*, since the Ramplaan case no sanctions were formulated nor applied.

Regarding the interactions and outcomes subsystems:

- Harvesting was changed to *harvesting of electricity* to clarify the function of the variable and what specifically was gathered.
- Within the outcomes variable group there are variables considering the social performance measures, ecological performance measures, and we added the *economic performance measures* to complete the whole picture. A large part of implementation of sustainable technologies involves investment and it would be unrealistic to make an analysis without including these financial resources.
- The externalities to other SES cases has been changed to only *externalities* in order to be able to describe them more freely, without the need to specify to which other SES systems the ICES was having an impact on, because for the modifications for ICES modified framework is not reliant on the SES approach to the variables.

All the variables from the actor subsystem and the ecosystem were maintained, because in a man-made ICES like the Ramplaan the actors and their governance determine what happens in the system. All variables are relevant and it is always good to take the potential for large scale changes into consideration.

7.1.3 MODIFIED FRAMEWORK

After all the described modifications were made, the final modified framework shown in table 13 was presented. This final framework excludes all the outtakes and has adopted all the proposed changes. From here forward, when we refer to the modified framework we refer to this framework presented in Table 13.

Table 13 - Modified SES framework suitable for the Ramplaan ICES case study.

Social, economic, and political settings (S)	
S1 Economic development, **S2** Political stability, **S3** Energy system: markets and technology.	
Resource systems (RS)	**Governance system (GS)**
RS1 Clarity of system boundaries; **RS2** Size or capacity; **RS3** Naturally occurring facilities; **RS5** Productivity of system; **RS4** Equilibrium properties; **RS4** Storage characteristics; **RU6** Mobility; **RU7** Growth or replacement rate;	**GS1** Government organizations: internal and external organizations **GS2** Non-government organizations; **GS3** Social network structure; **GS4** Property-rights systems; **GS5** Operational-choice rules; **GS6** Collective-choice rules; **GS7** Constitutional rules; **GS8** Monitoring rules
Resource units (RU)	**Actors (A)**
RS1 Predictability **RU2** Interaction among resource units; **RU3** Economic value; **RU5** Spatial and temporal distribution **RU6** Predictability of system dynamics	**A1** Number of relevant actors; **A2** Socioeconomic attributes; **A3** Leadership/entrepreneurship; **A4** Norms (trust-reciprocity)/ social capital; **A5** Knowledge of SES/ mental models; **A6** Importance of resource (dependence); **A7** Technologies available
Action situations: Interactions (I) -> Outcomes (O)	
I1 Harvesting of electricity; **I2** Information sharing; **I3** Deliberation processes; **I4** Conflicts among users; **I5** Investment activities; **I6** Lobbying activities; **I7** Self organizing activities **I8** Networking activities; **I9** Monitoring activities; **I10** Evaluative activities	**O1** Social performance measures; **O2** Ecological performance measures; **O3** Economic performance measures; **O4** Externalities
Related ecosystems (ECO)	
ECO1 Climate patterns, **ECO2** Pollution patterns, **ECO3** Flows into and out of focal SES	

Looking at the variables in this modified version of the SES framework for ICES, we came to reflect that all of the variables should have been considered by the Ramplaan Foundation and later the Cooperative as part of their planning for the solar PV project implementation. Had this happened, maybe it could have taken a shorter time to get the Ramplaankwartier neighbourhood to what it is today in terms of energy production;

maybe, even more technologies could have been adopted and the capacity of the system could be larger by now. To think in retrospect seems like a good exercise to qualitatively evaluate the achievements, the drawbacks and the possibilities for improvement. What we have seen from the analysis in Chapter 6 and the modified framework in Chapter 7 is that the governance variables are of high value for the implementation of a successful ICES. However, within the framework there is no distinction made between the importance of the variables. If there would be a tool that would organize the variables so that the initiators or policy-makers know which steps to take, better implementation could be a results. With this in mind, we designed what we called a “facilitation method” which takes into account all the variables from the modified framework and explains which ones seem to be more relevant, but also during what stage of the process, and thus need special attention from the initiators. Throughout the next section the facilitation method is presented and described.

7.2 FACILITATION METHOD

The research question of this project seeks to know to what extent the SES framework and Ostrom theories can be used to facilitate the Dutch Ramplaan case ICES. In this regard, so far we have used the SES variables to analyse the Ramplaan case, and then selected the applicable variables and modified the framework to fit the Ramplaan case. However, with only a modified framework we believe we give insufficient handhelds for potential project initiators like the Ramplaan Foundation and Cooperative to approach such an ICES project. If we give value to our research we need to provide a method that offers help with the actual implementation of the modified variables. This method could have then been used by the foundation and the cooperative the start of their project, hypothetically speaking. By keeping the variables of the modified framework, and leaving them open for interpretation, this method can then forth also be used for other cases apart from the Ramplaan because the method and variables allow for variation and case specific adaptations. In any case, it allows for further research on the level of applicability of our facilitation method for other ICESs.

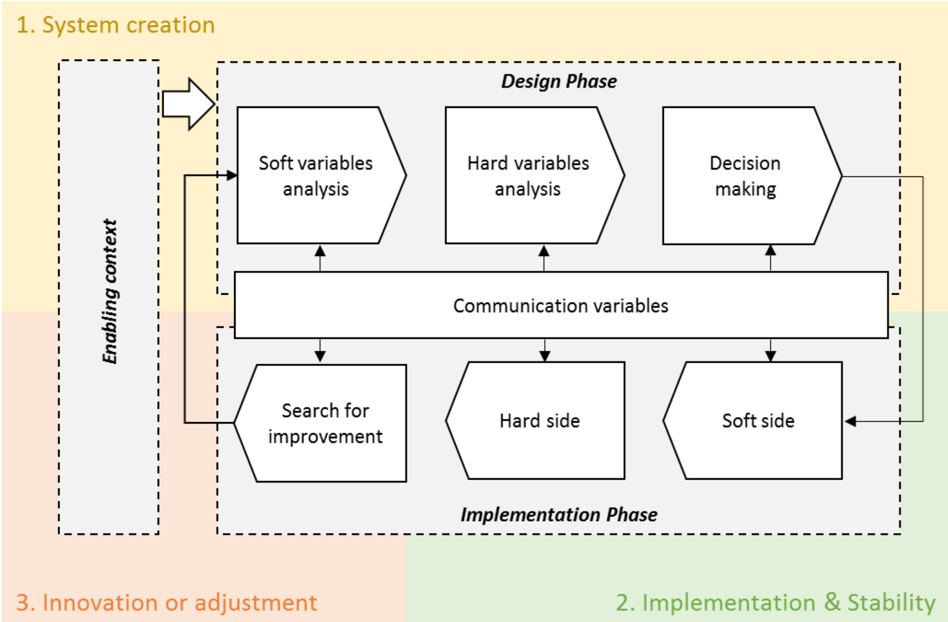
7.2.1 ICES’ STAGES OF DEVELOPMENT AND METHODOLOGICAL PHASES

The Ramplaan case experienced different stages of development. First there were local initiators who created the foundation to advance their environmental ideals, then there was the high level business case which gave a series of theoretical possibilities for development, and then there was the set-up of the energy cooperative that brought people together to actually implement the solar PV project. Our belief is that if the variables from the actor and governance system were had taken into account more prominently in the first stages of development, the project could have included more technologies and attracted more members quicker. From looking at the Ramplaan case only, we hypothesize that the development of an ICES can be explained by three general stages:

1. System creation, which involves: actor gathering, potential technology analysis and investment. Choices, rule establishment and decision making are central here.
2. Project implementation and a stability period.
3. System innovation or adjustment. Moving from an evaluation phase to system creation, which is affected by the acquired experience from the involved actors.

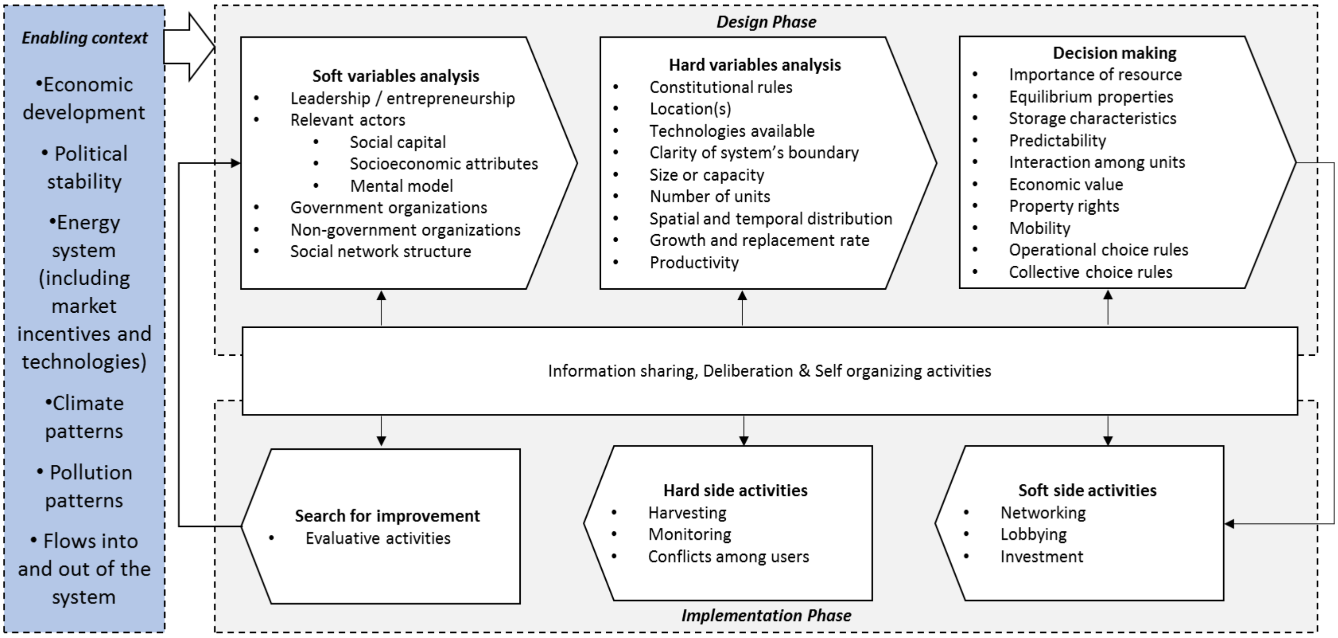
If we were to facilitate such an ICES, the SES variables would hold different degrees of importance depending on the stage the ICES is at. We therefore propose a method based on the Ramplaan experience to facilitate these three stages and overall improve implementation of an ICES project. The method holds three so called phases linked to the previous proposed stages (Figure 15).

Figure 15: Phases of the proposed method and linkage to proposed ICES' stages of development.



The facilitation method starts with the enabling context, which is required for the design phase to begin. The design phase is followed by the implementation phase, and throughout the latter two phases information sharing and deliberation are emphasized. The description of each phase in regard to the SES variables follows. The **enabling context** phase sets the context by looking at all the variables from the social, economic and political setting system of the modified framework and are analysed and qualified as appropriate or enabling. In fact, before any development away from the status quo of an area can be achieved, it would be important to properly lay out the preconditions to mark the boundaries of the potential ICES. By analysing all the variables of the social, economic and political setting, the initiators are able to clarify the current status of the larger system that could shape their local community energy system (Figure 16). The key variable in this case would be the energy system.

Figure 16: Enabling context phase and its variables.



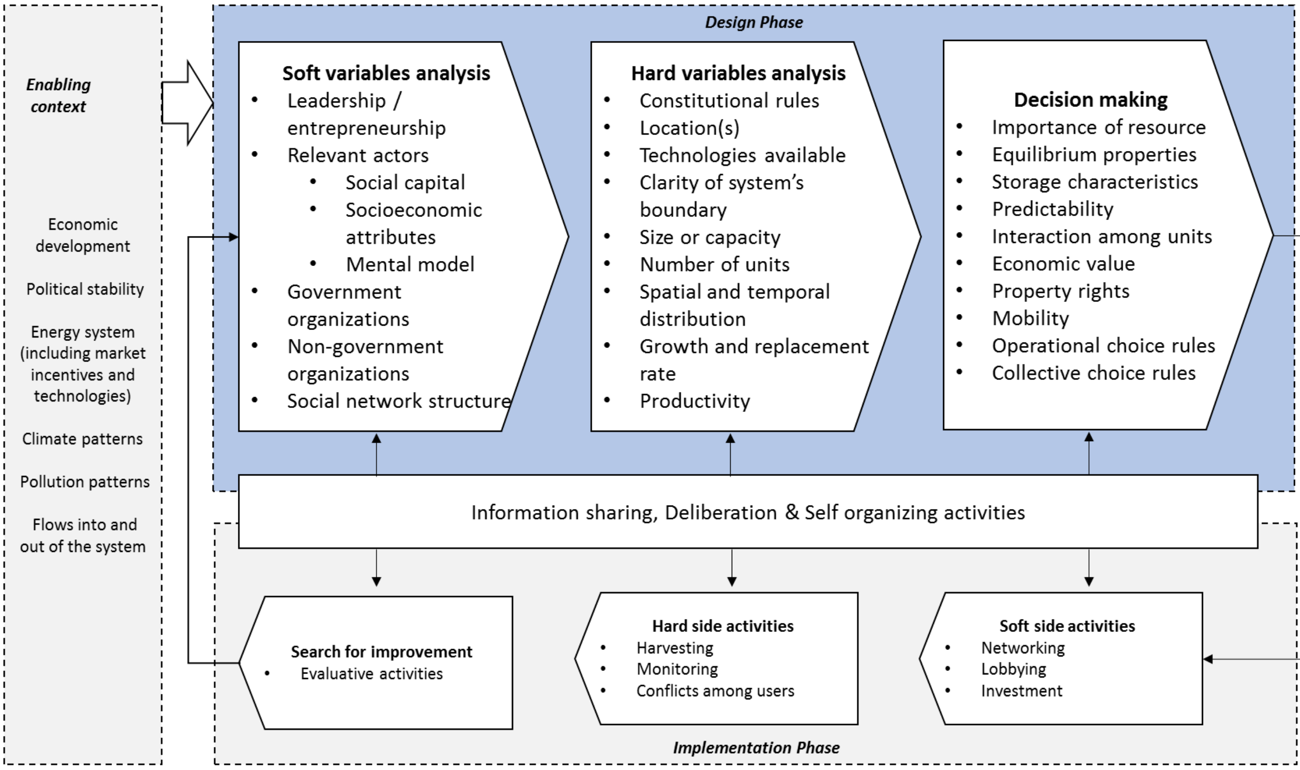
Design phase

The design phase constitutes of three steps: soft variables analysis, hard variables analysis and decision making. The first two steps do not necessarily have to happen in chronological order, but are iterative and thus influencing each other. However, we believe that the third step which is decision making, should only happen after the soft and hard variables analysis have been addressed. We believe that after having an enabling context in place, the next step should be to start developing a social network that can later be the base to (1) start depicting a concrete idea for the ICES, and to (2) establish a governance system for it.

In the Ramplaan case, the solar PV roof idea was first developed, and only afterwards the energy cooperative started recruiting members to join the project. Here we propose they should have started by setting up a strong social network and only later decide upon the project's technicalities and business model. All the social aspects of the ICES that have to be considered according to the modified SES framework variables are grouped into the step we called ***soft variable analysis***, for they are not easily quantifiable and subjective.

The second step is the ***hard variable analysis***, containing the more quantifiable variables, and it is concerned with looking at all the possible energy technologies and their combinations that could fit the community's needs and wants, available space, and available investment. In comparison to the Ramplaan case, this step could be regarded as the production of the high-level business case project document, as well as real-life feasibility studies after actual plan formation. Although the proposal the high-level business case made was not actually implemented, it certainly gave momentum to the solar roof project. We propose that the business case document that is produced with this facilitation method, used information from the soft variable analysis and so to also include a more social aspect like the community's engagement.

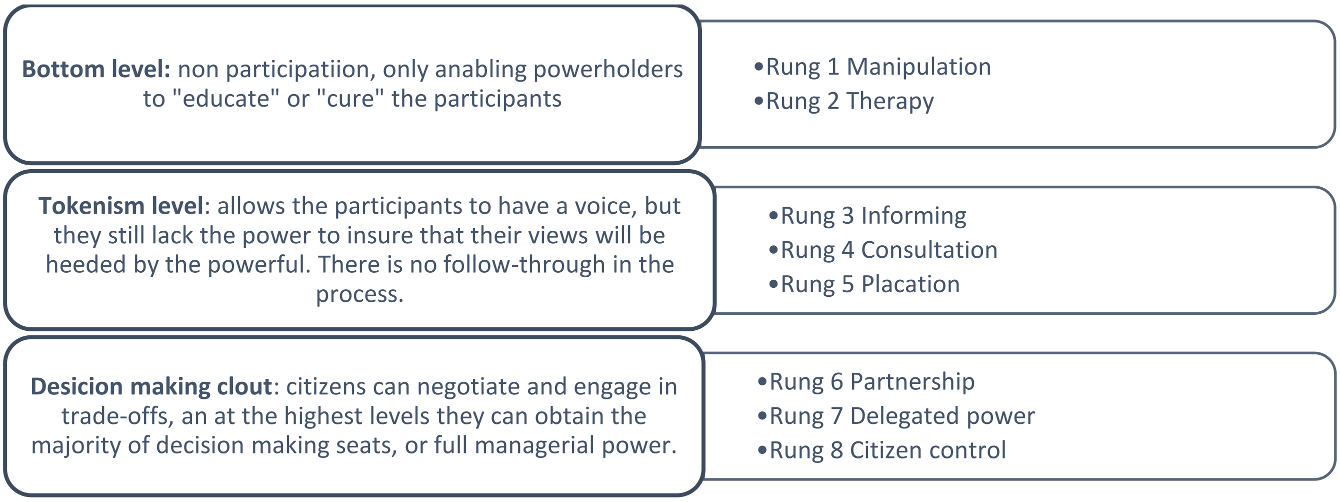
Figure 17: Design phase steps and their attached variables.



To come to the third step which is ***decision making***, we believe there has to be effective communication between the actors who participate (as leaders and as community members) in the soft variable analysis. A strong social network with a shared mental model on a community energy system has to be achieved. For this, the potential ICES has got to be understood; that means the hard variable analysis has to be communicated and discussed among the community members and the rest of the network that has been established in the soft variable analysis. Between these two steps (soft and hard variables analysis), possibly happening in parallel, information sharing, deliberation and self-organization has got to be a constant throughout the process. By doing so the cooperative can reach a moment when *decision making* starts happening organically, creating a system where change is gradual, automatic and slow rather than suddenly and through enforcement. Variables among step two and step three are highly interlinked. We believe the variables we selected for the decision making step would influence the resulting business case document from the hard variable analysis step.

The outcome of the design phase would be a high level business case, addressing economical, technical and social aspects, under a horizontal governance approach where community members are engaged in decision-making. A note on a theoretical model to enhance governance is appropriate at this point. Back in 1969 a ladder of citizen participation was proposed by Arnstein (1969, 216) claiming that "participation without redistribution of power is an empty and frustrating process for the powerless. It allows the power holders to claim that all sides were considered, but makes it possible for only some of those sides to benefit". Figure 18 shows the levels of citizen participation and the rungs of the ladder of participation. We believe that for an ICES to kick off in the best possible way, the decision making clout level with rungs 6, 7 and 8 has to be implemented from the design phase.

Figure 18: Levels of citizen participation (Based on Arnstein, 1969).



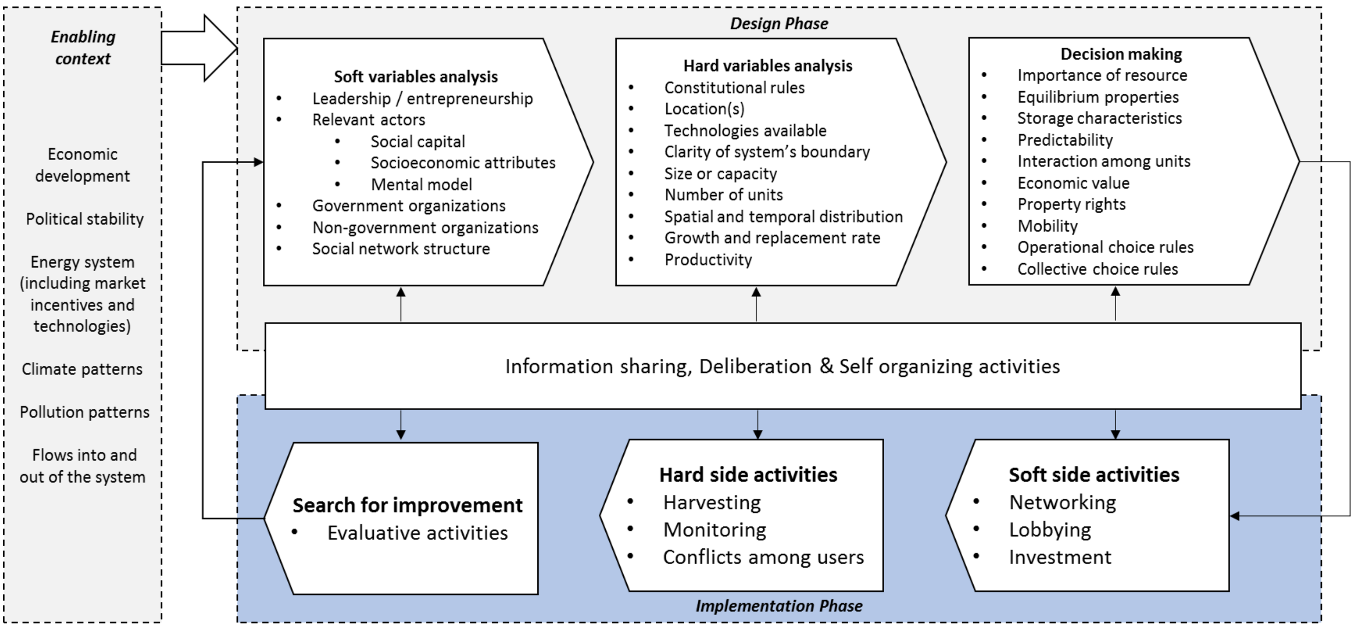
Once the governance system is in place and the idea for the ICES is summarized into the governance business case based on the community´s needs and wants, implementation can follow. It might be redundant to emphasize how important governance seems in the design phase of an ICES, but nevertheless we believe it is worth mentioning again. In his book about how the Samsø island in Denmark achieved its fossil free status, Søren Hermansen explains that next to sharing a common between community members they also need to reap benefits from a certain level of autonomy. "Arbitrary interference from outside is no good. It is also important to engage all the local players: that everybody who uses the common is genuinely involved in how it is run" (Hermansen y Nørretranders, Commonities = commons + communities 2013, Chap. 4).

Implementation phase

Once the design phase is mostly in place, the implementation phase (Figure 19) starts at a group of **soft side activities** as a first step. These are networking, lobbying and investment. We believe that once all the members from the community are included and also recognize themselves in terms of what they can individually contribute to the project, the soft side of implementation should develop organically through self-organization. As it happened in the Ramplaan case, members who had connections to the government or had insights into lobbying activities took this task upon them to get the Postcoderoos policy benefit to be economically interesting. The board of commissioners from the Ramplaan cooperative did the required networking getting in touch with the energy provider Qurrent, and the municipality, who subsidized part of the prior investment. Only after having the networking and lobbying in place, the business model was settled upon and investments by members were set on paper. We believe that if this phase is preceded by the building of the shared mental model with a governance approach, the members' decision to invest would be easier because the whole process would have been based on community trust and the achievement of shared goals.

After the soft side activities are attained, the hard side activities are related to actual results from implementation. They include harvesting of energy and monitoring. Here we believe possible conflicts among users have to be dealt with as well. Although the review on ICES literature showed some main barriers that requiring further research are potential free riding behaviour and split incentives, we did not identify such problems within the Ramplaan case or the desk review on other cases. Both Søren Hermansen from the Energy Academy in the Samsø island and representatives from the Foundation and energy cooperative of the Ramplaan case seemed surprised when asked about these types of behaviour. Both mentioned that as members of the community the goal is not to be protective of whatever has been achieved, instead you want to share it and expand it. Also, by making the membership take as little energy as possible for the members, there incentive to start a project individually is very low and often required a higher investment for a similar outcome. (Jan Wattel 2016) Søren went on to explain that the difference between the community and a business enterprise is that, although you can also generate jobs while getting a need covered, your goal is not to make profit. He explained there are some things business companies would never be able to provide at the detailed level the organized community in Samsø can for themselves (Hermansen, director of Samsø's Energy Academy 2016). As another example Sabine Jansen, a former member of the Ramplaan Foundation, explained how in the first year of the project, five board commissioners used to work at least five hours per week to get it running; and she looked surprised when asked if these individuals were paid. The insight we got into how energy communities function is that most of it is about good will, but that success comes with a mixture of enthusiasm, sufficient expertise and effective organization. All this justifies that the *conflicts among users* variable did not seem to be very relevant in practice, but we still think it should be kept in mind for further research, and these examples do not provide sufficient foundation do disregard any possibility of conflict.

Figure 19: Implementation phase steps and their attached variables.



The final step of the implementation phase is search for improvement. Change can only follow a necessary period of harvesting and monitoring activities. Here is where leaders raise their voice for change at any scale, big or small.

Search for improvement could not really be observed in the Ramplaan case because the energy cooperative is at this exact point. They are assessing their options for change. And we dare to suggest that the way to decide upon the next steps for the neighbourhood could be optimized if the method we are suggesting as part of this research project is considered. Currently, the chairman considers it would be a good idea to merge the Ramplaan with other cooperatives that operate in the area. Because of the sustainability goals of Haarlem, Wattles explained that there are other local initiatives that focus on other technologies have people working there as a fulltime job. According to him, merging the Ramplaan Cooperative with such an initiative could take the whole ICES to a next level. However, member approval is essential, because the board does not have, or want to have, the power to make this decision by themselves. Meanwhile, the Ramplaan Foundation is working together with TU Delft to come up with a new proposal of high level business case to take the Ramplaankwartier neighbourhood off the gas grid.

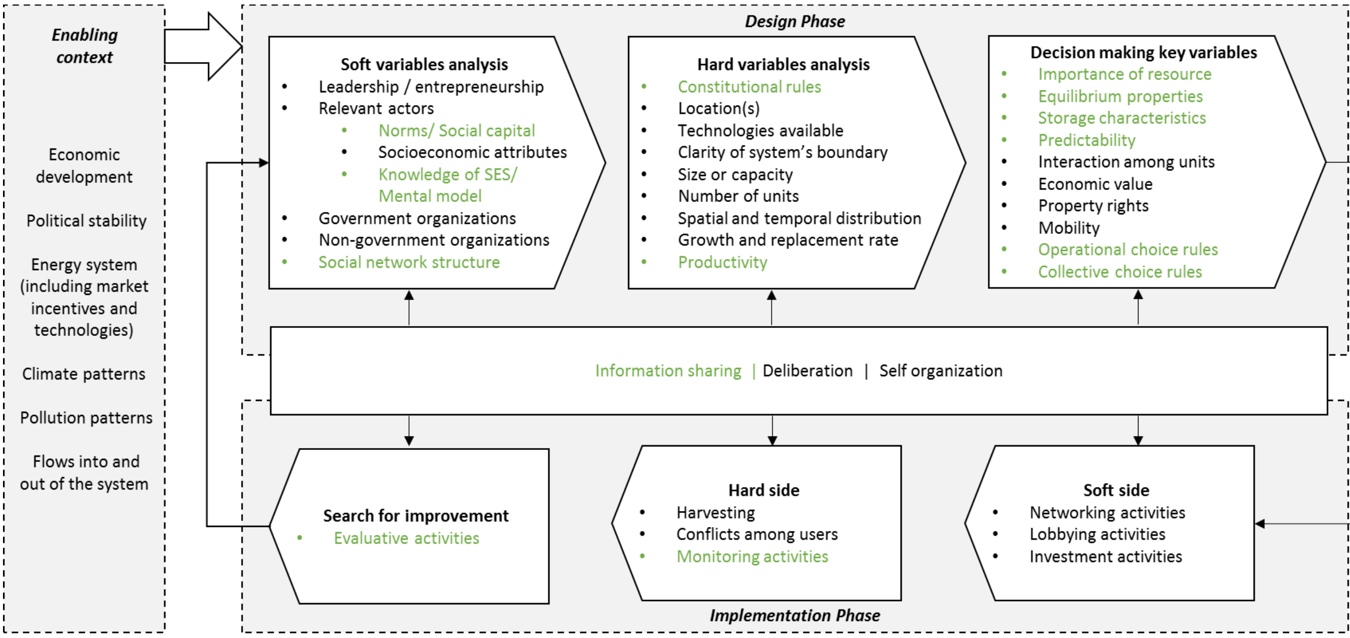
While some of the interviewed actors involved with energy cooperatives in The Netherlands are doubtful about decentralization being desirable (Koekkoek 2016), others acknowledge it as the future, with storage being available everywhere (Wattel 2016) (S. Jansen 2016). This brings us to think that even in a successful ICES like the Ramplaan, shared mental models need a lot of work be maintained. But how to do it exactly? With the proposed method we certainly do not believe to be reinventing the wheel. The steps really follow a Plan, Do, Check, Act cycle, an interactive process, but in the next section we give insight into what we consider the key variables in each of the proposed method steps. To achieve each variable, we proposed specific tools or theories from our industrial ecology background that help answer the how question.

7.2.2 THE KEY VARIABLES OF THE SES VARIABLE APPLICATION METHOD

This section presents the selected key variables for each one of the steps in the proposed method. We believe that to achieve the best outcome in each step, which is to obtain the best possible result out of the key variable, several theories and tools from industrial ecology can be useful. The section is organized by the steps of the design and implementation phases.

Figure 20 shows the selected key variables for the proposed method. They are fifteen variables, justified in the following lines.

Figure 20: Key variables in the proposed facilitation method (in green).



Information sharing variable

As a starting point it is worth explaining the information sharing variable, which does not belong to any step but is part of all of them. From socials scientist specialized in the commons field of work, we learned that this might be the most essential variable among the key ones.

Findings from Janssen et al (A multimethod approach to study the governance of social-ecological systems 2011) explains the importance of communication, implying that resource management can be influenced more by communication than by the rules crafted around it. In empirical experiments, it turned out that organization of communication is more important than the content of it (Poteete, Janssen y Ostrom 2010). Building trustworthy relationships within the community for successful and efficient implementation is essential and was in fact mentioned during all the interviews we conducted for this project. Trust is the base to construct a social identity, which is related to building a strong sense of collective identity and in turn motivates a person to join the collective action representing the social identity (Bamberg, Rees y Seebauer 2015). In fact, Bamberg (2015) suggests that more frequent contacts and group activities over time are desirable in order to gain group identification and build group norms. In turn, this should enhance participative and individual efficiency as well.

Information sharing in the Ramplaan case was mostly done through flyers and mouth to mouth communication. To improve these processes, we propose to use social norms marketing campaigns (SNMC). SNMC provide specific normative information that can serve as a point of comparison for an individual's own behaviour. In short, this sort of campaign should promote both a descriptive and an injunctive norm with the intention of gaining more followers and keeping the ones already gained.

As background information, descriptive and injunctive norms are informal norms as opposed to formal, codified one such as legal rules. The injunctive ones reflect perceptions of what others approve or disapprove of, and motivate action because of the social rewards and punishments associated with engaging or not engaging in the behaviour. Smith (2012) states that descriptive norms reflect perceptions of whether other people actually engage in the normative behaviour themselves and motivate action by informing people about what is likely to be effective or adaptive behaviour in a particular context.

SNMC can come in the form of flyers, using both have been proved effective in gaining followers while retaining the already participating ones by reinforcing the message. Schultz (2007) analysed 287 households in California were studied in the framework of SNMC to decrease energy consumption. After measuring the baseline, the researchers would give descriptive-norm feedback and in some cases (for the non-control group) happy ☺ or sad ☹ faces to communicate the injunctive norm. The descriptive normative information with no emoticons given led to an undesired increase in energy consumption for the households that were already consuming less than the average for the neighbourhood. But when the injunctive message was added to the descriptive normative feedback, households that were consuming less energy than average continued to consume at the desirable low rate.

Soft variables from the design Phase

We chose three variables as key ones for the first step of the proposed facilitation method: *social capital*, *mental model* and *social network structure*. Their outcomes greatly depend on the facilitation given the people in the community playing the leadership roles. Although we do not specify it as a key variable because we consider it as a predisposition, evidence from existing ICES suggest that leadership emergence relies on individuals with outstanding motivation and sometimes expertise to implement a community based energy system (P. B. Koirala, et al. 2016). These actors usually take a leading role in projects which mostly have entrepreneurial character. Looking at the progression of the Ramplaan case, we can see that the creation of the foundation and the cooperative was slow and progression to the next stage was slow. This was due to the lack of previous experiences with energy cooperatives and knowledge about how to govern them.

Leaders must bear in mind the added value of energy cooperatives. According to Boons & Baas (1997) there are five reasons why cooperative relations add value, next to the desire to be autonomous. They establish a more horizontal integration of actors which increases technological development and on a smaller scale technology acceptance. Secondly, they increase the speed of acceptation by inhabitants that disfavour the technology either aesthetically or functionally. Also, they enhance a growing of culture and trust, which is a necessary condition to innovate their day-to-day business and achieving an increased level of education. Understanding these value additions in advance of cooperating can improve leadership by getting together the right actors to make the design and implementation processes easier.

Now, concerning the chosen variables, we believe the outcome of this phase should be to create a shared *mental model* based on the *community's social capital* that can then give rise to a strong *social network structure*. This structure should be regarded as key to share information and make decisions.

The creation of a shared mental model can be enhanced by the SNMC, but we believe it has to have a more solid ground. If the energy cooperatives are mostly about doing good while benefiting the wellbeing of the community, we believe a task for the leaders is to find out what people in the community care about, what their current knowledge on ICES and from there on build a common ground. What can be the basis to build a common ground targeting a shared mental model on implementing an ICES? Hard to say. But since we found that it is not about profiting nor getting much cheaper energy, at least in the Netherlands, we believe environmental ethics could be explored.

Philosophers like Peter Singer advocate for rich humans, or those who at least have more than their basic needs covered, to care and do good for the world. Since energy systems are directly related to the climate change issue it would be worth asking as a community what are the group´s moral obligations in regard to climate change? Topics like future generations and intergenerational justice will appear here. Callahan, for example, states that "we owe to those coming after us at least what we ourselves were given by those who came before us: the possibility of life and survival" (Callahan 1981, 77). Golding approaches the subject by merging the needs of future and current generations when referring to people living in many disadvantaged places in developing countries. he says "we would be ethically well-advised to confine ourselves to removing the obstacles that stand in the way of immediate posterity´s realizing the social ideal. This involves not only the active task of cleaning up the environment and making our cities more habitable, but also implies restraints upon us" (Golding 1981, 70).

Philosophical arguments can be regarded as not useful for many, but for some they might be even related to religious beliefs. What we want to emphasize here is that we believe leaders, or facilitators, should figure out what is important among the different community members. The starting point of the design phase might be getting to know the neighbours more in deep. Answering why would each type of person in the community would join an ICES can be a good ground to design communication campaigns. Bamberg (2015) suggests there are four influential pathways to collective action: cost benefit, collective efficacy, group based emotions and social identity. Social identity and collective efficacy were already mentioned concerning the information sharing variable. Group based emotions refer for instance to anger resulting from unfair collective disadvantage. As for cost benefit, the author implies that collective action would be motivated by both the individual cost benefit and the identification to group goals.

Hard variables from the design phase

The key variables for this phase are *constitutional rules* and *productivity*. While constitutional rules will be directly related to the energy system from the context variables they need to be considered as the framework that can make implementation possible or not. Also because based on these rules, lobbying activities might be necessary.

The technology availability depends on the financial capacities of the community, the physical characteristics of the location, the market situation in the respective community, and the regulatory environment. Lastly, all technology must conform with national technology standards and regulations. The regulatory development might differ between regions. This is evident for smart grid technologies, for example, whose rate of adoption is slowed down due to insufficient regulations (Blumsack and Fernandez 2012).

Concerning productivity, we believe this is a key variable because it can be the one setting a clear objective for the ICES. And in fact, defining the desired productivity can also be related to knowing why people would join the initiative. The motivations to join an ICES are various and include inter alia potential energy cost savings, reduced environmental impacts from energy as well as opportunities to stimulate local economy, even inside the community. In this sense, the productivity of the system can be evaluated in different terms. We propose a set of performance criteria which accommodates all these objectives, whereby we follow the reasoning on infrastructure performance by Finger et al. (2005). Performance criteria are economic, public value and technical system integrity:

- The economic performance of a system can be measured with a set of straightforward indicators, for instance, generation cost per unit of energy, investment cost per unit of generation capacity, or system costs per unit of energy. These indicators can be expressed in monetary terms.
- The public value performance is more multifaceted than the economic performance and consist of consumer interests and collective interests. While consumer interests incur to individual consumers, collective interest benefit the society as a whole, and have public good characteristics. One main public collective value of ICES is the reduced environmental impact from energy consumption in terms of reduced GHG emissions, which can be expressed as emission savings in tCO_2e per unit of produced energy. This is a quantitative indicator, yet, this indicator is influenced by the chosen baseline. The baseline can be set for example as the average carbon share of energy from the centralized grid for a given base year. Further public consumer values include reliability of supply (expressed as hours of disruptions per year) and energy security.
- The performance of technical system integrity describes system characteristics. This may be interconnectedness of nodes, resilience of the system, etc. Quantitative indicators for technical system are not as straightforward as for public value and economic performance, and performance may be described qualitatively.

Now, while the trio of economic performance, public value performance, and technical system integrity describes the ‘hard facts’ of performance, they fail to describe the building of social capital in the community through ICES. For instance, areas where ICES were initiated later experienced an increased willingness of inhabitants to engage in other bottom up initiatives. For instance, the project at Samsø Island increased the willingness of the inhabitants to come together to provide collective transportation and internet services, and has significantly improved the community social cohesion (Hermansen, director of Samsø's Energy Academy 2016). This was not planned to happen, but rather did organically. However, what we want to emphasize is we believe that it might be a good idea to define a desired productivity from the beginning of the project, during the design phase; and that productivity can be linked to the core reasons of why the members of the community choose to participate in the ICES collective effort. If the point is to do good for the world, leaders could start gathering ideas from the current sustainable development goals.

Decision making for the design phase

The decision making key variables we selected can be divided into two groups. The first group deals with the technical potential of what an ICES can be designed upon. The second set deals with the social approach to make choices based on rules.

Concerning the technical group of variables, we chose: importance of resource, equilibrium properties, storage characteristics and predictability. Based mainly on these four variables, the rest of the technical decisions can be made. Coming back to the proposed facilitation method, the idea for making this variables key ones is that they can be accounted for when developing the so called high level business case under a governance approach. We believe the consultants (or the actors who would be putting together the project document) should take into consideration the following questions:

- How important is the availability of energy (the resource) at all time for the members of the community?
- That would open the discussion to the equilibrium properties of the system. Will they be willing to go off the grid? What would the available technologies to achieve decentralization be?
- And if so, what can of storage characteristics are needed?
- How predictable does the system need to be to comply with the community needs?

Concerning the *equilibrium* variable, for an ICES which is interconnected to the centralized grid and is a net exporter of energy, the size of the resource system overstates the energy demand of households in the system. Inversely, for an interconnected ICES which is a net importer of energy, the size of the resource system understates the energy demand of households in the system. Predictability studies can indicate the opportunities for the potential ICES and given an indication of the size that suits the situation best. This can be dependent on factors such as the community, the environment, the suitable technologies, the demand or the available investment.

System equilibrium is crucial for system functioning of off-grid ICES which are not interconnected to the centralized grid. In the short term, the equilibrium state can be maintained with demand side management measures and operating reserves. Demand side management, for instance aided by smart grid technology, allows to temporarily reduce or shift energy demand in the system. The equilibrium can be maintained without additional generation. Operating reserves are highly responsive power plants which can compensate quickly for shortages in generation capacity. However, these have high variable costs and are typically gas fired power plants or pumped hydro storage, which is out of scale for a community-sized ICES. An alternative operating reserve is battery storage, if affordable or bankable.

In the long-term, the equilibrium of a system can be maintained through investments in additional generation capacity. This is necessary if the demand grows through increased user number or through energy consumption per user, new capacity. Alternatively, energy efficiency programs or other demand side portfolio programs, such as for load shifting, can flatten out the load duration curve of a system and allow to supply more users without expanding generation capacity.

System equilibrium is a matter of system function especially for off-grid ICES, in which non-equilibrium causes supply disruptions. In interconnected systems, the state of non-equilibrium is compensated with energy exchange with the centralized grid. With regard to short time equilibrium, interconnected ICES compensate temporary capacity shortages through imports from the centralized grid and supply disruptions do not occur more frequently than in the centralized grid. In the long term, ICES typically aim at zero net-imports from the centralized grid or at being net exporter to the centralized grid, which requires investments in generation capacity as the user base grows. It is noteworthy that interconnected ICES are by no means autonomous from the centralized grid, even interconnected systems which are net exporter depend on the centralized grid to compensate intermittency of renewable generation during lulls.

The functioning and resilience of ICES can be improved through energy *storage,* which reduces the risk of disruption caused by intermittency of renewable energy systems and supports the load balancing. Traditional storage systems such as pumped hydro power is out of scale for community sized ICES. Emerging technologies such as batteries, for instance in combination with an electric vehicle concept, are just at the start of market penetration and will play a greater role in future ICES systems.

Interaction among resources can increase the interconnectedness and resilience of an ICES, and therefore its *predictability*. The higher the interconnectedness of the network, the higher the resilience. For instance, the hierarchical treelike network with one-directional flows from a central resource to branched nodes, which represents the structure of the traditional electricity system, is not resilient to withstand disruptions at the central resources. Contrary, a web structure of nodes without central resource but distributed resources at nodes can withstand minor disruptions without that the entire network function is disrupted (Economides, 1996). The web structure describes well a smart grid with bi-directional smart meters, demand side response, and distributed energy generation. Generally, the network structure and especially the interconnectedness of nodes has a significant impact on network resilience, whereby resilience increases with interconnectedness.

For the analysis of this group of variables we previously mentioned the need of consultants thinking that it can occur, as in the Ramplaan case, that the community does not have a member who is an energy expert. We believe that analysing and deciding upon these variables which will shape the ICES technical design needs expert advice.

Coming to the second group of variables, which are *operational choice rules* and *collective choice rules*, we believe the theoretical findings from the grammar of society from Bicchieri (2006) and the grammar of institutions by Crawford & Ostrom (1995) can be useful when institutions are being set up. Grammar of institutions can be used when setting up formal rules for the ICES operation, while grammar of society can be used to steer the development of social norms among the ICES community.

The development rules and their influence into outcomes for the Ramplaan case were hardly analysed even when we tried to get more insight into the process. We were not able to grasp if norms and rules were specifically established at some point based on a governance process and how and why that happened. The main institution in place is the contract the members signed when joining the energy cooperative. But besides that the social norms and social sanctions could not be really explained by the interviewees. We believe this might be due to the fact that this sort of information is only shared when trust has been built. And also that social norms and sanctions are not always acknowledged but simply known.

We believe that choice rules variables need further research work, but as a mean to guide the proposed facilitation method, theory how social norms are constructed and how formal rules can be conformed can be useful for the facilitation leaders, or simply facilitators, to apply.

First we briefly explain what grammar of society or social norms are about. When following any norm, individuals are (maybe unconsciously) cooperating. In terms of governance of a common good, it is important to understand why people choose to either cooperate or defect. Thøgersen (2008) has proved that injunctive and descriptive norms work synergistically to promote cooperation in social dilemmas. He proved the following hypothesis:

- Cooperation in everyday social dilemmas increases with the belief that others cooperate (descriptive norm)
- Cooperation in everyday social dilemmas increases with the belief that relevant others expect one to cooperate (injunctive norm)
- There is a positive interaction between descriptive and injunctive norms with regard to fostering cooperation, meaning that the combined effect of the two types of norms is bigger than their additive effects.

In fact, these hypotheses are based on Bicchieri´s theory. According to her grammar of society, a social norm of promise-keeping is a behavioural rule that is followed only if certain conditions are met. The conditions are (1) targeted people must know the rule, and (2) they conditionally must prefer to conform to it. Furthermore, they would choose to conform because either: (1) they believe that a sufficient number of others will also conform, or (2) they believe that a sufficient number the others expect him/her to conform.

Now, the grammar of institutions which we believe can be used to facilitate the making of collective rules and sanctioning rules (if needed) is briefly described.

Crawford and Ostrom (A grammar of institutions 1995) consider that an institutional statement encompasses rules, norms and strategies. To define each type of statement the following five components should be taken into account:

- [A] - Attributes: holder of values of a participant-level variable distinguishing to whom the institutional statement applies
- [D] - Deontic: holder of modal the verbs “may” (permitted), “must” (obliged), and “must not” (forbidden)
- [I] Aim: holder that describes particular actions or outcomes to which the deontic is assigned
- [C] Conditions: holder for variables defining when, where, how, and to what extent an aim is permitted, obligatory or forbidden.
- [O] Or Else: holder for variables defining the sanctions to be imposed for not following a rule.

Strategies are written using [A], [I] and [C]. Cumulatively, norms are written with [A] [D] [I] [C]; and rules as [A] [D] [I] [C] [O]. If [D] exists in the statement (in norms and rules), it is expected that negative repercussions follow behaviours that do not conform to whatever is expected, and that positive rewards apply in the contrary case.

Another key term used in the grammar of institutions are “delta parameters”, which are eroded or improved depending on the compliance with the institution. Deltas are the change in expected payoffs from either obeying or breaking a prescription. This is of use when analysing cooperation and the institutions in context. Although we have been emphasizing that our findings from the Ramplaan case show that ICES is about willing and cooperation and that no conflicts were acknowledged by the interviewees, we believe for more complex ICESs might need to work on more complex institutional configurations.

Soft side of implementation

As seen from Figure 20, no key variables were chosen from the soft side of the implementation phase. We assume that all of the variables concerning this step are important but contingent. They could happen if possible, if needed, if the situation allows. They will be an outcome of information sharing and self-organization variables. In this section the tool we believe is appropriate to suggest for lobbying under community self-organization. This is known, legally, as collective action. A Dutch example concerning climate change can serve as example of what can be achieved.

In November 2013, Urgenda Foundation, a non-governmental organization, started proceedings against the Dutch State. The collective Urgenda was representing sought that the Dutch State would commit to limit the amount of CO_2 emissions to 40% below the 1990 level by 2020 (Urgenda Foundation 2014). They argued the government was violating international law by setting lax targets for the country. After the suit was submitted the government appealed, but it did promise to work towards achieving a 25% reduction target in 2020. The final resolution is yet to be reached, but it has been mentioned that this case has inspired citizens and organizations from all around the world and that climate litigations are becoming more popular (Urgenda 2016).

Hard side implementation and Evaluation for improvement

The last key variables to discuss are monitoring and evaluation. Monitoring here should be understood as the day to day or periodic update on indicators measuring the harvested energy, the state of the technology infrastructure, the possible conflicts or preoccupations among community members regarding the ICES´s functioning. Evaluation on the other hand is a more difficult process. It involves looking at the monitoring results, the related variables and the outcomes over a longer period. Evaluation tries to measure the impact over long term objectives.

Which tools are available regarding monitoring and evaluation? For monitoring we suggest smart meters (as used in the Ramplaan case) are the best option. Issues with smart meter adoption, at least in the United States, have to do with households feeling like the energy company is gathering personal information that could later be used for purposes different to managing the grid equilibrium (Bakke 2016). But when a community sets to manage their electricity, like it can be in the case of an ICES, this problem disappears if there is trust within the community members.

Regarding evaluation, we dare to suggest that including an external party to facilitate evaluation would be the most suitable way to, as a community, come to a conclusion of what is there to improve, why and how. Why was the desired productivity achieved or why wasn't it? Public policies and development organizations rely on evaluation to know if the resources they are spending on certain projects are achieving the expected results. This is not a topic being explored up until now for ICESs, since they are merely becoming to surge, but we believe that the optimum way if a community is aiming for effectiveness would be to conduct formal evaluations. Available tools for this matter would be publications on MRV (monitoring, reporting and verification) from climate change mitigation literature and theory of change literature from economics. More specifically and maybe practical, facilitators could gain insight on the topic from a how to guide about social return of investment (SROI) from an UK national network on social value. The SROI guide provides a framework to measure social value or social impact, and it is related to wellbeing and sustainability (Nicholls, et al. 2012).

7.3 ICES ORGANISATIONAL PLAN: APPLYING THE FACILITATION METHOD

Having described the proposed facilitation method, and seeing that it might be difficult to follow the link between phases, steps and variables, this section suggests a practical approach to implementation. So we devised an ICES organisational plan to make the facilitation method easier to implement and understand in practice. Here we explain a process that can be followed by those interested to create their own ICES. This part provides a practical methodology to implement the variables of the facilitation method. It shows where the variables should be used and how they are applied several times in diverse order. It also helps those developing an ICES to consider, analyse and plan for situations that could be overlooked.

Also, the ICES organisational plan shows the importance of implementing a plan that is structured and flexible to adapt to the specific needs each ICES has to consider.

This plan was made based on a business plan structure taken from Wolk's (2008) report Business Planning for Enduring Social Impact, which was adapted to ICESs' needs. The reason why it is based on this business plan is because it provides a working order and is oriented towards attaining social objectives. The Ramplaan and other ICES mentioned in Chapter 3 are presented as examples to show when they implemented either a given variable or how they acted on different parts of the plan. The SES variables used in the plan are mentioned in italics.

7.3.1 PLANNING TO PLAN AN ICES

Before beginning the plan, it necessary to consider the first steps that should be done. This can be considered as a "Planning to Plan" phase. The initial people interested should make a planning work group. They have to choose leader (variable: leadership) and a small group (of about 5-7 people) to help with ideas and decisions. The group should develop a decision making process, to ensure that communication is constantly flowing (variable: information sharing). Deadlines and meeting schedules should be made planned beforehand to keep a well-defined work structure.

The most relevant actors need to be determined, so that the stakeholders can be updated on the advance of the process of developing the ICES, and to assess those that should be part of the decision process (variable: social network structure). In order to make them part of the decision process, frequent information exchange should be done. Some examples of implementing this exchange could be online forums, newsletters and meetings (variable: information sharing). In this way constant feedback to the process of developing an ICES will be ensured and stakeholders will be involved since the very beginning which will facilitate the implementation of the organisational plan in further steps.

This phase will set the pillars for the development of the ICES's organisational plan. The outcomes from this phase will be further developed and detailed in the following sections.

7.3.2 ARTICULATING AN ICES

The aim of this part is to formulate an organisational model that connects the problem the ICES can solve for the community.

Problem Definition

The problem that the ICES wants to solve has to be clearly defined and understood, so that the ICES can determine the best approach for their specific case. To achieve this, the first step is to perform a need and current situation analysis. The need analysis will give more insights on the community's social, cultural factors so that the energy need and sustainability interests can be determined with enough information instead of being assumed. The current situation analysis consists of making an overview of all the enabling context variables (main variables from this group: economic development and political stability), as they will show the current trends in the community's location (from a local and national perspective) which will help understand possible opportunities and threats to the ICES.

With this information a hypothetical structure and approach of the ICES can be modelled, to describe ways in which the ICES can make an impact on the community energy management (variable: mental models). This will provide an argument to explain the importance of the ICES for the community (and other stakeholders) and why is it being done now.

REPOWERBalcombe defined its problem by wanting to avoid fracking and its environmental consequences in the Balcombe area. So their ICES was a way to cover their energy requirements without relying on polluting techniques like fracking.

Vision of Success

The ICES needs a vision that declares how a broader success can be assessed within possibilities. This shows a long-term goal that can motivate and inspire stakeholders, mainly community members (variable: norms).

Social and Economic Impact Indicators

In order to achieve the vision of success, ambitious but realistic targets should be set. Indicators provide progress assessments that show the impact of the ICES. Three to five indicators that will measure the vision will suffice to begin with (variables: monitoring and evaluative activities). Monitoring in this case is not related only to the energy produced (as we mention in chapter 6 when describing this variable) but it is still refers to processed that are specifically adapted to monitor. This applies to the use of this variable in the rest of the organisational plan.

Some examples of social and economic indicators are: jobs created, amount of renewable energy generated, total electricity generated, ratio of renewable energy produced to the total energy demand of the community.

Mission

A mission should describe the ICES target beneficiary (or beneficiaries), the activities conducted by the ICES to address its target problem, and the outcomes that the ICES will reach. This will allow to measure internal procedures and evaluate what the system should do.

Operating Model

The operating model is how the ICES's activities will work together to achieve the mission above. An operating model analysis has to be developed, as it helps to review the ICES planned activities and shows opportunities to improve. The analysis can be done using information of other ICES or community projects, as well as feedback from the community members (variable: information sharing). Also, supporting organisations like the ones mentioned in chapter 3 can be contacted in this stage to get first-hand information. The Ramplaan did this by contacting HIER Opgewekt.

The result will provide vital information for operation of the ICES, like details of the community that is being targeted, staff positions needed, the project costs and an explanation on how the ICES activities work together to achieve the mission (hard variables, main ones: economic value, productivity). As the operating model is put into practice, it can (and should) always be improved/adapted according to the ICES's development.

Social Impact Strategies

This part is done to develop strategies that will be the main actions the ICES will focus on to achieve its mission and improve its operating model, in order to achieve its (long-term) vision. Like the operating model, these strategies are a constant work in process.

Organisational and Program Performance Indicators

These are more internal indicators, which are based on the social impact strategies. The objective is to measure the ICES's capacity to implement its organisational plan (variables: monitoring and evaluative activities). So, short-term results have to be evaluated to determine how this implementation is going. The indicators will show the progress of the ICES when carrying out its operating model and social impact strategies. This is why the indicators will also act as a feedback loop to improve them.

Some examples of organisational and program performance indicators are: number of members, ratio of members to the total community population, energy saved by members since they joined, and hours done of volunteer work.

7.3.3 ICES IMPLEMENTATION STRATEGY

By now the ICES should have more of a shape and order of what it will include. The following section builds up in a more detailed and clear way the aspects discussed in the articulating an ICES part.

Governance

In order to ensure that the human capital is enough, the governance capacity has to be assessed. In order to do this it is important to list roles, responsibilities and skills needed to implement the social impact strategies. Since at least initially an ICES depends on volunteers, it is important to define their roles and the amount of work they will need to do, to estimate how many volunteers will be needed.

Another important aspect to determine is how the ICES will select and implement decisions (variable: collective-choice rules). This should be mainly a task of the community members involved (or interested, depending the case). One example could be monthly meetings to update members/interested/the community on current developments. Samso has the Energy Academy as a meeting point for its members (Energy Academy 2011).

A suggestion is that each member has the equivalent of one vote, no matter how many shares the member owns, as this avoids members having more power than others. ICESs like The Ramplaan do this. Energy4All fosters the ICES it helps to do it this way as well (Energy4all 2014). Also in this stage it should be determined if a board (made up from members) will in general manage the ICES and what will be its role and of its members (variable: collective choice rules).

Technology

This is one of the main aspects to consider within an ICES, as the technology chosen for generating electricity will determine costs (initial costs, maintenance costs), energy savings, and the appeal of people to join. One major energy source technology (e.g. wind turbines, solar panels, etc.) should be chosen to begin with, considering the most available renewable resource the community has, which will include the space where the technology will be implemented (variable: size or capacity). A plan that chooses the best technology applicable for the community will need to the detail the type of technology, its costs, how much energy it will produce, what is the minimum amount of members needed to join to afford the technology and what is the maximum amount of members that an ICES can have with the technology before needing to scale up (variables: productivity, technologies available, number of units, spatial and temporal distribution, growth and replacement rate). An example on how aspects can be considered to scale up technology is generally modelled in chapter 8.

Additionally, an integration plan could be made to assess later the additional technologies that can complement the initial one. This can be quite useful for the starting ICES to ensure integrating energy solutions, which is the ultimate aim of an ICES. This plan should consider the community's needs and allow flexibility as the community's needs will probably change in the future. However the integration plan should not be too detailed because it is likely to become quickly outdated, as the energy-related technologies and prices tend to change fast (variables: interaction among units, importance of resource, storage characteristics).

Financial Sustainability

Most ICES face two major financial challenges: they do not have a track record and need high investments to start-up. Combined, these aspects make it hard to find investors.

Therefore, to lure investors it is important to show that an ICES can be profitable in diverse aspects. It is important to note that profitability in this case does not only consider monetary rewards but social and environmental gains as well. The gains that need to be shown will differ on the type of investor.

We identified five main categories of investors in ICES: new/existing members, financial institutions (eg. banks), private investors, public investors and volunteers. Each has to be addressed in a different way, based on their reason to invest. Below there are general examples of how to address each:

1. **New/existing members:** to attract members, the payback period should be considered from an energy point of view. For example, the ICES should clearly state the years it will take for the savings in energy to cover for the investment cost of becoming a member. The largest the amount of the total

initial investment that can be covered by the members, the less the ICES has to rely on financial institutions and the faster that the ICES can implement its energy generation idea.

2. **Financial institutions:** they are able to provide major loans as long they consider that they can be paid back in an acceptable time (which will depend on the institution). Hence, these investors want to know the monetary profit that the ICES can achieve.
3. **Private investors:** they can be any private entity and are usually interested in monetary profits. However, they might also offer to invest in return of something else. In chapter 3 we mentioned the example Fintry, which made a joint-venture with a wind-farm developer. There is not much detail in what did the joint-venture consist on, only that Fintry received a wind turbine (Local Energy Scotland 2016) but we don't know what the wind-farm got in return. However, it is logical to assume that when Fintry expands and needs more wind turbines, it will buy them from the mentioned developer. Other examples are the partnerships that NDT and Feldheim did with private companies.
4. **Public investors:** they are part of either the local, regional or national government. These investors tend to look for non-monetary profits. They are more interested in social profits like job creation and environmental profits like carbon-neutrality. For example, in Dawson Creek the municipality is highly involved and works on creating policies that will ease the ICES. In Samso, some of the wind turbines are owned by the municipality (Visit Samsø 2015).
5. **Volunteers:** they will invest their time on the ICES, so it is important for them to know if the time they can invest is worth it. Volunteers can be skilled or unskilled, and both need to have clear ideas of what are they expected to achieve and how long approximately it will take them. When calculating the ICES future costs It is important to consider that at the long run, some roles performed by volunteers should become a paid job.

All the costs related to the ICES need to be taken into account. These costs should be: long term, short term, related to the energy generation, building, administrative and marketing costs.

Due to the high costs an ICES has to cover, the most recommended is to receive funds from diverse types of investors *(variable: investment activities)*. In order to attract the diverse categories on investors the ICES needs to have a clear financial plan that shows the different types of profits that can be obtained and how they will be achieved. Some examples will follow. The main monetary profit will be the resulting money gained from selling energy to the grid. There are other monetary examples like future workshops to teach those interested in create an ICES. Samso does something similar with its Energy Academy. The social profit could show a plan of the amount of jobs created annually due to the ICES and how long-term will these jobs be. Fintry invested its monetary profit made from its wind turbine to create social profit by providing free insulation to half the town's homes (Local Energy Scotland 2016). The environmental profit, which is linked to the energy savings, can be calculated for the amount of renewable energy generated, how much less carbon is being consumed. Samso aims to be fossil free by 2030 (State of Green 2014).

Communication and Marketing

It is important to have clear messages to reach key stakeholders in an ICES *(variable: networking activities)*. That is why the ICES has to determine the standards and systems it needs to communicate in a frequent, consistent and convincing way *(variable: information sharing)*. The groups of people that an ICES wants to target on its communication are also the same mentioned in the financial sustainability section plus any additional partners. Also, volunteers could be considered as a different category but they are likely to come from the same pool where new members come from. So, depending on the case, volunteers can be considered as a different category to target communications to.

With partners we mean all possible organisations that could be interesting for an ICES. Different areas for partners should be considered depending on the ICES needs. For example, to ensure technical expertise to operate a wind turbine, the ICES could partner with a technical university which could provide students specialised in wind technology.

A major aspect to consider in this stage is to research and select which companies, organisations and groups are the ones that fall in one of the investor categories, so that it is clear how to develop a communication strategy for each, based on what they are interested to know from the ICES.

Once the message and the receivers are determined, the resources that the ICES needs should be considered. They mainly are:

- **Branding standards:** a logo, communication templates, etc.
- **Communication materials:** a web site, brochures and other public documents, news articles, press releases, newsletters, a calendar of publications to communicate to each investor category, events.

An example of resource use: for communication to the community to get new member prospects the ICES can: create a newsletter, inform about frequent meetings (either on a weekly or monthly basis) that anyone in the community can join, develop information days, etc. *(variable: networking activities, social network structure).*

Public Policy

An ICES is quite dependant and vulnerable on public policy, as in order for an ICES to be financially competitive with renewable energy, it needs government support. Subsidies, tax reductions and FITs are some main examples. As mentioned in chapter 3, countries like Denmark, Canada and the United Kingdom have applied them to an extent to develop steady community energy projects. Some of them evolve into an ICES, like Samso. The postcoderoos policy was quite beneficial for the Ramplaan. On the contrary, we should recall REPOWERBalcombe's negative experience from a policy change that reduced by 65% the subsidy available for solar panels, which paused a 4.8MW solar farm as it was no longer economically feasible.

That is why it is important to analyse thoroughly public policies that might influence the ICES *(variable: constitutional rules)*. Within this analysis key governmental institutions and jobs should be determined as well as the current or potential policies that can affect positively or negatively. This should be constantly updated in order to prepare the ICES for upcoming changes.

Risk Mitigation

When developing the ICES and also specific energy projects within, it is important to have contingency plans to minimize risks. The ICES should determine one or two main aspects it needs to succeed and check which risks relate to them.

As mentioned above, public policies provide opportunities as well as risks to an ICES *(variable: constitutional rules)*. In the example of REPOWERBalcombe, if they had done a contingency plan, they would not have relied only on subsidies for financial feasibility, but would have devised other sources of income, which would not have paused the last stage of the solar farm development.

Performance and Social Impact Measurement

This section is made to review and further develop the indicators created in the "articulating an ICES" part. They will now be assessed and improved if needed in order to create a reliable and regularly applicable self-evaluation system. First, the indicators' baselines (if any) and targets have to be stated. Then, a schedule for measuring and reporting the indicators should be established. Afterwards an explanation of usage of the data collected has to be done so that a clear feedback loop can be created to improve the operational model and the impact strategies. Finally, a report template should be developed in order to communicate to investors and other stakeholders the ICES's progress and social impact.

Action Plan

The ICES is now ready to be operational, so an action plan should be devised to assign specific people to be responsible of a specific goal. This plan should also include deadlines and activities to achieve the agreed goals.

7.4 CONCLUSION: GENERALIZATIONS TOWARDS THE DESIGN OF AN ABM

The SES framework has been described in literature as a bold and ambitious tool (Epstein, et al. 2014). We used it to design a method to facilitate the Ramplaan case ICEs if were to start again using disciplinary tools focused on sustainability and energy systems. We dare to suggest that our method can be easily generalizable, but should be tested on other cases first to make proper adjustments if needed.

What is more generalizable among the phases and steps? We believe phase 1 on enabling context and phase 3 on implementation are already applicable to any ICES. However, the design phase would need more considerations but still we left the all the technical variables that would be needed in order to shape the technical part. The outcomes for the social part are contingent. We described a series of theories from scientific literature to enhance effective communication and participation, but in the end it is about human relations.

In the hope that technical systems can further help predict human behaviour within a system like an ICES, the next chapter will explore whether an agent base model (ABM) for the Ramplaan case can bring further useful insights to the analysis.

8 MODEL OF THE INFLUENCE OF SELECTED SOCIO-TECHNICAL SYSTEM VARIABLES ON THE MEMBER-NUMBER DEVELOPMENT IN AN ICES

In previous sections of this report, we adjusted the SES and IAD framework to accommodate analyses of socio-technical systems and particularly ICES. For this, we considered various technological, social, and institutional requirements which affect the emergence of an ICES. Some of these variables directly shape social patterns and interaction between ICES-members at a community level. We built a simple agent based model (ABM) to explore how these identified general variables of the environment influence decision making at the local level and ultimately determine the emergence of an ICES.

Since ABM has the capacity to represent entities which perform actions and make decisions, and effectively interact with their environment, it is an appropriate tool for this kind of research. (van Ham, Nikolic and Lukszo 2013). It distinguishes from equilibrium methods, which can analyse aggregate outcomes of systems but do not consider individual decisions of actors in the concerned system.

To make use of this tool, we translated selected variables of our developed framework in the ABM environment NetLogo. These variables have been identified as especially important during our research on the De Ramplaan. Subsequently, we conducted experiments to gain insight how these variables influence the emergence of an ICES, i.e. the growth of both member-number and installed capacity.

The following sections describes the setup of the ABM and provides an overview of the results we obtained. We set up our ABM according to the 8-step procedure described by van Ham et al. (2013), whereby we adopted the methodology slightly.

8.1 PROBLEM FORMULATION AND ACTOR IDENTIFICATION

Throughout our research, we focus on the perspective of ICES proponents, i.e. stakeholder with a strong interest in the successful implementation and emergence of communal energy systems. We do not further specify the problem owner(s), this role can be assumed by households, a municipal body, or an ICES initiative. The identified variables include both elements of the general environment as well as factors at community level, for which the problem owners have different degrees of influence.

The objective of the ABM is to analyse how the variables of our adapted STS framework influence the emergence as well as the development of user number and total installed capacity of an ICES. The results provide additional information on which constitutional rules are essential to ensure a successful ICES implementation.

The model design represents a simplified system for two reasons. On the one hand, setting up a model which includes all suitable DER systems and the full complexity of transaction between members is out of scope of this research. On the other hand, we only aim at obtaining a general understanding of influences of the variables on the system, which does not require a full representation of the system's complexity.

A primary selection of variables included leadership/entrepreneurship, constitutional rules, storage characteristics, and predictability. These are all included in the developed framework as described in chapter 7. These framework variables are translated into system variables based on empirical results from DE Ramplaan, as follows:

Leadership/entrepreneurship describes the capacity of the cooperative to increase awareness for the system to promote membership. In DE Ramplaan, these activities are carried out voluntarily by cooperative members. We assume that the more voluntary time spent to promote the system, the more awareness there is among households in the community.

In context of an ICES, constitutional rules describe sector regulations which either restrict or promote the emergence of an ICES. In De Ramplaan case, two regulations had significant influence on the project: Firstly, the *postcode roos* law offers tax break for ICES members for every generated kWh. Secondly, big energy generation installations require a large consumer grid connection. This connection can cause high costs. The cooperative of De Ramplaan successfully lobbied so that their ICES exempted from these connection costs.

Storage characteristics of an ICRES describe its ability to store electricity. Storage requires investments, but can also increase profitability of the system if cost savings from using generated electricity on site are higher than from feeding into the grid. There are currently no batteries installed in De Ramplaan, therefore, this system variable was not implemented in the model.

The variable of predictability describes whether member-numbers and installed capacity follow a foreseeable pattern. This variable was not included in code in the model, however, we expect that results of experiments will indicate if and under what conditions system development is predictable.

8.2 SYSTEM IDENTIFICATION AND DECOMPOSITION

This section described the system setup which is used to analyse influence of variables on an ABM. This includes an explanation of agents, their states, relationships, behaviour, and interaction.

We assume a community of 1000 households. There is one energy cooperative in the community, which operates a PV installation at a centralized location within the community. Households buy shares in the system if they have a certain awareness for the system and if the expected payback period id acceptable. The cooperative processes requests from households that want to become member of the cooperative. It also conducts promotional activities the system to raise awareness among the households, and expands installed capacity if there is sufficient demand.

Spatiality has no effect in the system., i.e., agents do not move within the system and their distance from each other has no influence on their interaction. One tick of the model represents one month. The model stops either after 20 years (240 ticks), or when the maximum installed capacity of 850 kW has been reached. The growth rate of the system is affected by the buying decision of households, who evaluate the expected payback period based on cost for one system share and realized savings on energy costs (both is explained in more detail below). The growth of installed capacity and user number over time allows conclusions on the effects on system variables on system development.

8.3 CONCEPT FORMALIZATION AND MODEL FORMALIZATION

This section describes how the model was formalized. Actor behaviours, rules, and environment were first described in a narrative and then formulated in pseudo code. We explain the most important system components briefly.

8.3.1 THE ENVIRONMENT AND SYSTEM SETTINGS

Households and the cooperative are in one action space in which spatiality has no effect on system outcomes. The temporal horizon of the system is 240 ticks. One tick represents one month, thus, the model spans over maximum 20 years. Following global variables were included:

Sunshine peak hours

Sunshine peak hours determine productivity of PV panels, whereas annual generation is the product of sunshine peak hours [h/a] and the capacity of the respective technology [W]. We assume 1500 sunshine peak hours, which is an estimate for the Netherlands based on climate data from Deutscher Wetterdienst (2017).

Electricity market price

Members of De Ramplaan are customers of energy provider Qurrent. Qurrent buys the generated electricity from ICES members at EUR 0.07 (HIER opgewekt 2015).

Technology costs and capacity

A market research was carried out to determine typical technology costs and capacity for PV panels. We assume a technology costs of 3400 [EUR/kW], which is the 2011 market price for medium scale PV systems (including mounting system, installation, converter, etc.) in Germany (IRENA 2012). We are aware that technology costs have reduced meanwhile, however, we expect that this value is adequate to obtain meaningful results from our analysis. We assume that our system consists of 285 W PV panels, such as the product LG285S1C-B3 from LG (LG Electronics 2015). One share of the energy system equals 1 kW installed capacity at EUR 3400 and 3.48 panels. The cooperative expands the system in steps of 5 kW with a total technology cost of EUR 17000. Households cannot own more than one share.

8.3.2 CONSTITUTIONAL RULES

There are two constitutional rules which affect the cost profitability of ICES: The *Postcode-roos* law and the large consumer connection.

The Dutch *postcode-roos* law was introduced in 2013 (Power Leaf Group 2017). It offers tax breaks to members of energy cooperatives. A tax break of EUR 0.09 per kWh generated is granted for members who live in the four-digit postcode area in which the installation is located, or in an adjacent post code area. This amount is deducted from the tax households pay on their electricity bill.

If the law is not enforced (i.e. false), energy cost saving of members equal the product of produced energy [kWh] and received price for electricity 0.07 [EUR/kWh]. If the law is in place, members additionally receive 0.09 EUR per generated kWh. This reimbursement is considered in the calculation for expected payback period, which non-member households do to evaluate the option to join the ICES.

A large consumer connection is required for energy generation entities of a certain size. This can increase costs for energy cooperatives significantly. The cooperative in De Ramplaan case successfully lobbied for an exemption of these costs. We include the large consumer connection as a *true false* slider in the model. If the large consumer connection is *true*, the connection costs need to be paid by members. The costs are staggered by capacity size (see table 14).

Table 14: Large consumer connection cost (Liander 2017)

Installed capacity (kW) / number of shares	Connection costs per share [EUR]
< 50	0
50-84	304.57
85-134	246.40
135-534	64.36
535-850	108.06

If connection cost is true, the first 50 households who join the system (i.e. 50 shares à 1 kW capacity) need to pay EUR 0 connection costs. Once the capacity of 50 kW is reached and if total capacity is no more than 84 kW, every new member must pay EUR 304.57 connection costs. The model assumes that maximum member-number is 850, which equals an installed capacity of 850 kW. The costs per connection were obtained from Dutch DSO Liander and it is not clear what determines the pattern (i.e. it seems that there is no linear relation between connection costs and member-number).

8.3.3 MONETARY TRANSACTIONS

Aim of our model is the to gain insight in the development of member-number over time. Profits of individual households or the cooperative are no key-indicator for this, therefore, the model does not include monetary transactions (e.g. in form of an 'bank accounts'-attribute of turtles).

8.4 HOUSEHOLDS

There are 1000 households in the system which are implemented as turtles. Their attribute is awareness, whereby initial awareness is 0. Every month, the cooperative provides consultations of two hours each to selected households, which raises their awareness by 0.2, respectively. Moreover, awareness of all households decreases by 20% every month.

Behaviour of households can be described as profit maximizing. Every round, households which are not member of the cooperative and which have an awareness of at least 0.2 for the ICES decide whether to apply for membership. To do so, the costs (i.e. technology costs and where applicable connection costs) are compared to expected return of investment and where applicable savings on the electricity bill. If the calculated payback period (i.e. ratio of total costs and annual benefits) is lower or equal the accepted payback period, households apply for membership. Based on empirical results from the De Ramplaan cooperative, we assume an accepted payback period of 13 years.

8.5 THE COOPERATIVE

The cooperative has the objective to maximize installed capacity and member-number of the ICES.

To promote membership in the ICES, the cooperative randomly selects households which are not member and which have an awareness lower than 0.4 for consultations of 2 hours each. The amount of hold consultations is determined by the available voluntary time of the cooperative. Based on empirical results from De Ramplaan, we assume that there are 50 hours available per month, which represents approximately 10 full working days per month (including time for preparation and follow up). However, we vary the amount of available hours in our experiments. One consultation session increases the awareness of the respective household by 0.2.

Cooperatives proceed member requests and commissions expansions of the system. Every month, the cooperative checks if there are at least 5 requests from households to join the ICES. If so, the cooperative randomly selects 5 households of the applicants to become member and expands the installed system capacity by 5. The candidates who are not selected make a new buying decision the following month (given that their awareness for the system still is higher than 0.2). We do not include pending membership requests for households whose application was refused because if the connection cost switch is set on “true”, it is possible that the connection costs will have increased in the coming round, and the previous evaluation of payback period may lose validity then. An expansion of 5 shares of 1 kW each equals 17.4 PV panels with total cost of EUR 17000. We assume that this is the maximum expansion which the cooperative can commission every month. Moreover, the maximum installed capacity is 850 kW with 850 members. No household can hold more than one share and members cannot sell their share.

8.6 SOFTWARE IMPLEMENTATION AND MODEL VERIFICATION

The concept formulization was translated into a pseudo-code to prepare implementation in NetLogo. The final code was obtained in an iteration of coding and debugging and is included in appendix 1.

Subsequently, model verification was conducted to test whether the model performs as intended, i.e., whether the model formalization was translated into code correctly. For this, we verified whether the model produces reasonable results for a set of tests.

- Households’ colour changes from blue to yellow when they become member of the cooperative → **true**
- Households’ colour changes from grey to blue when they apply for membership → **true**

- At the end of one iteration no household's colour remains blue, as rejected membership requests are not pending → **true**
- One tick is one month and the count for year reaches 20 years after 240 ticks → **false, checked, fixed, true**
- Either none or five households join the cooperative every tick → **true**
- The total member-number does not exceed 850 → **true**
- The model stops running when a member-number of 850 is reached → **true**
- The model stops running when year count of 30 is reached → **true**
- No household becomes member of the ICES when the accepted payback-period is set 0 → **true**
- There will be an error (division by zero) when the sunshine-peak-hours is set 0 → **true**
- No household requests membership if sunshine-peak-hours is set 1 → **true**
- The connection cost increases by increments as member-number increases → **true**
- After running the model, the maximum expected payback period of all households equals the minimum expected payback period of all households if slider for connection costs is false → **true**
- After running the model, the maximum expected payback period of all households is unequal the minimum expected payback period of all households if slider for connection costs is true → **true**
- No household requests membership of the slider for voluntary work is set 0 → **true**

8.7 EXPERIMENTATION AND RESULTS

Experiments were conducted with the BehaviourSpace tool of Netlogo. For this, the model was run 10 times for 12 scenarios respectively, whereby for every scenario the variables of postcode roos (true or false), connection cost (true or false), and voluntary work (45, 50, or 55 hours) have an unique combination.

The results of ten runs for each of the 12 scenarios was analysed in Excel. Table 15 lists the 12 scenarios with their respective variable setting and mean results for member-number and runtime. Moreover, figure 21 provides diagrams of the development of member numbers over time in ten runs for six successful scenarios. Mean, minimum, and maximum values are included.

Table 15: Variable settings and results of analysed scenarios

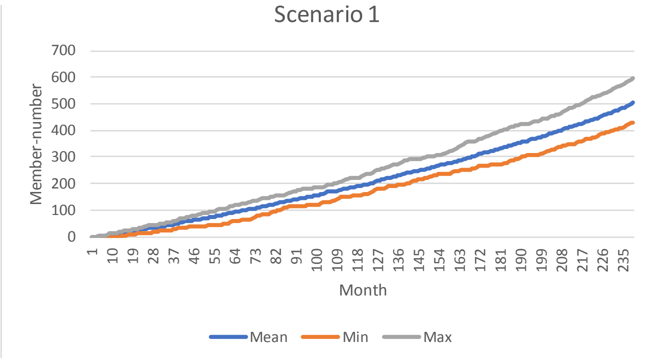
Scenario	Experiment settings			Results (Means from 10 runs)	
	Voluntary work [h]	Connection cost	Postcode roos	Runtime [months]	Member-number
1	45	True	True	240	506.5
2	50	True	True	238.7	819
3	55	True	True	216.8	850
4	45	True	False	240	0
5	50	True	False	240	0
6	55	True	False	240	0
7	45	False	True	240	492.5
8	50	False	True	239.7	810.5
9	55	False	True	216.3	850
10	45	False	False	240	0
11	50	False	False	240	0
12	55	False	False	240	0

Analysing the modelling results provides insights on the relative influence of the three tested variables on system development. There are six scenarios in which the variable setting is inadequate to attract investments in the system, namely scenario 4, 5, 6, 10, 11, and 12. These have in common the absence of the postcode roos tax break, which therefore must be a basic requirement for ICES development.

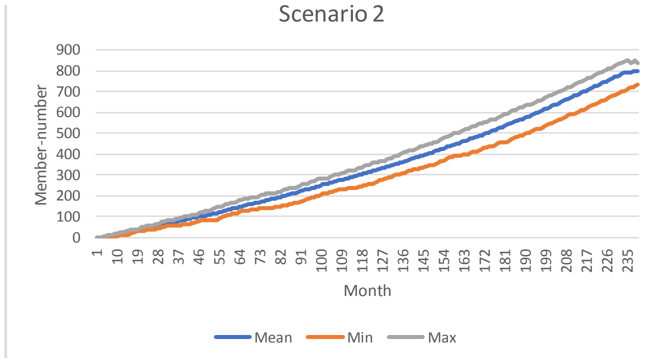
In the six scenarios where postcode roos is true, namely scenario 1, 2, 3, 7, 8, and 9, the connection costs appear to have only small influence on the member number, all other variables being equal. This can be seen from comparing scenario 1 with scenario 7, scenario 2 with scenario 8, and scenario 3 with scenario 9. Between these, the reached member number differs only slightly, whereby the highest difference – 14 members - is observed between scenario 1 and scenario 7. However, it is not clear whether this difference is a direct result of connection costs. Another explanation would be the criteria that only households with an awareness of 0.2 invest, whereby awareness is distributed randomly among households and makes the system outcomes dynamic.

Lastly, it appears that all other variables being equal, the availability of voluntary hours impact the development of member numbers significantly. Comparing scenario 1 with scenario 3 and scenario 7 with scenario 9 for which the voluntary work differs by 10 hours, respectively, we observe differences in member number outcomes of 342.5 and 357.5, respectively. Scenario 3 and scenario 9 both reached maximum member number before the maximum runtime of 240 months. We conclude that the tipping point for optimal voluntary hours is within the range of 45 and 55 hours. In future research, we would analyse the impact of variations in available voluntary hours in smaller intervals.

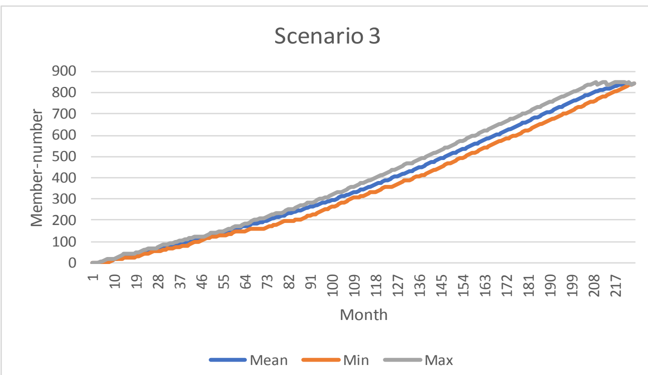
The optimal conditions are realized in scenario 3 and scenario 9. In both cases, a member number of 850 is reached and the runtime differs only by 0.5 months. All variables but connection costs are equal for these two outcomes, which supports the conclusion that the impacts of connection costs on system development are rather small.



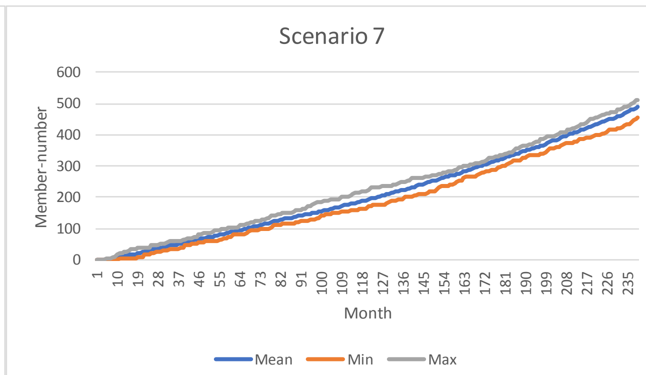
A setting with 45 h voluntary work, connection costs and postcode roos resulted in 506.5 members after 240 months.



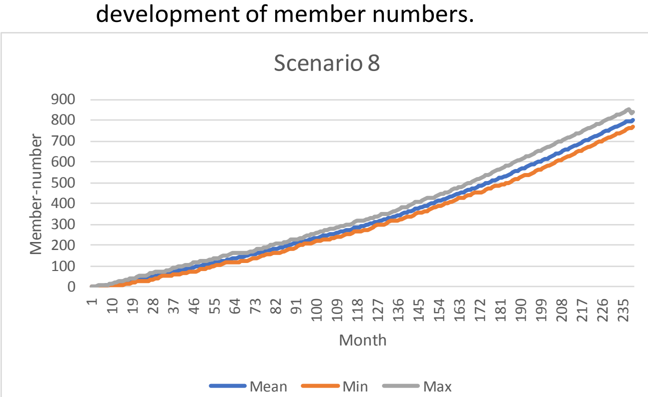
A setting with 50 h voluntary work, connection costs and postcode roos resulted in 819 members after 238.7 months.



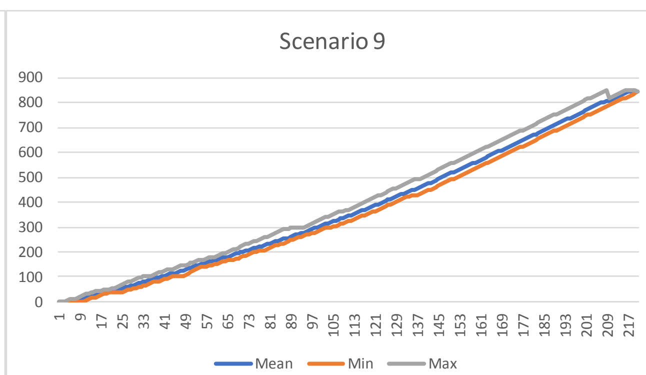
A setting with 55 h voluntary work, connection costs and postcode roos resulted in 850 members after 216.8 months. Only scenario 9 has slightly better conditions for development of member numbers.



A setting with 45 h voluntary work, no connection costs but postcode roos resulted in 492.5 members after 240 months.



A setting with 50 h voluntary work, no connection costs but postcode roos resulted in 810.5 members after 239.7 months.



A setting with 55 h voluntary work, no connection costs but postcode roos resulted in 850 members after 240 months. This is the best case scenario, very closely followed by scenario 3.

Figure 21: Results of scenarios with Adequate Variable Setting

8.8 ABM CONCLUSIONS AND RECOMMENDATIONS

Our agent based model allows some general conclusions on the influence of selected variables on system development. However, a more sophisticated model is needed to represent the full complexity of actor decisions. The selected model variables represent mainly environment factors and a deeper understanding of system dynamics may be obtained from including interaction behaviour between households, such as learning effects from neighbours, social clusters within the community, attitude of community leaders, etc.

With respect to the three variables selected for analysis, we derived following conclusions:

Leadership, represented as capacity to promote awareness for communal energy projects, appears to have significant influence on member number development. Households only invests in systems they know of, even if the expected payback period offers a good return on investment. We assume that in practice, not only the cooperative leadership but also existing members promote awareness among households who are not members yet. However, these learning effects between households are not included in the present model.

Of the two constitutional rules, the *postcode roos* is a precondition for emergence of ICESs. Without this tax break, the payback period is unacceptable. This has implications for energy policies of The Netherlands, i.e., this support mechanisms should be kept in future revisions of energy laws. The connection costs on the other hand appeared to have no significant effect on user number development. The De Ramplaan case successfully lobbied for exemption of these costs, however, it seems that the project could have been implemented even if connection costs had to be paid.

For the scope of the model, we analysed predictability not as variable, but rather seek to derive conclusions from general insights from the experiments. When looking at the diagrams in figure 21, we see that the range of possible developments is not significant, that is, the minimum and maximum results from the model do not differ significantly. This implies that outcomes of systems are predictable to a high degree if variables are fixed. However, we assume more variance in results from a more sophisticated and dynamic model which includes more interaction and learning between users.

9 DISCUSSIONS AND CONCLUSIONS

For this research, it can be concluded that the analysis of the Ramplaan case has showed that the SES framework proposed by Ostrom is applicable for the Ramplaan as an ICES, but lacks a tool that facilitates the implementation of the governance principle of the framework. According to the lessons learned from the Ramplaan case, we managed to propose a modified framework that is more suitable for the specific case, and could be assumed to also fit other ICESs. Furthermore, we have applied the knowledge from the analysis to develop a method that enables initiators such as the Ramplaan Foundation and the Ramplaan Cooperative board members to improve the adoption and implementation of their ICES. The method does not only allow for the initiators, or other policy makers, to take all relevant variables into consideration, it also gives them guidelines as to the order and way they should approach the variables. Furthermore, this research has given an initial set up for an ABM model that tries to predict behaviour on ICES in The Netherlands based on empirical evidence form The Ramplaan case. To elaborate on the conclusions, throughout this chapter we will try and discuss the findings of our report to give some critical reflections on the research questions.

The main goal of the report was to answer the research question *to what extent are the SES framework variables by Ostrom are applicable to an ICES and how can they help to improve the implementation of an ICES in The Netherlands based on the case from the Ramplaan Energy Cooperative in Haarlem.* Since an ICES can take many shapes and forms, we chose to analyse one specific case, which allowed for a more precise and thorough walk through all the variables. By doing so, the relevance or irrelevance of each variable became apparent and provided information of the development of the modified framework. The research question encompasses several facets and was therefore divided into several sub-questions which will be discusses separately.

The first sub-question aims at analysing each variable for the case and modifies the SES framework to be suitable for an ICES, which in this project was the Ramplaan case. The development of the framework consisted of four elements: relevant variables, irrelevant variables, wrongly located variables and missing variables. Initially it was expected that since the difference in nature between an SES and ICES, there would be a substantial amount of variables not applicable, or difficult to assess. However, with the framework Ostrom developed she tried to accompany an inclusive framework for all types of SES. As a result, most variables were well applicable to the Ramplaan case. This is because SESs and ICESs are about complex systems. Still, some of the variables were outtakes or modified to fit our case. The main apparent difference is that based on the human-facilitated background of an ICES, the variables that allege more governance related topics seem to have higher relevance for the analysis of the Ramplaan case.

Variables that appeared to be less relevant were those who were applicable to describe the context and the sector, since the latter is always energy in an ICES. Similarly, the context is almost always human-facilitated as well and can thus be changed according to the findings of other principles. Concerning context setting, the only relevant variables are those describing the economic, social and infrastructural factors. Some variables that led to modifications and relocations within the framework concern the resource unit, which is different in an ICES because energy is a less tangible resource than those of a SES. To be able to describe and interpret the variable correctly, some variables were renamed or rearranged.

Although Ostrom does not make any distinction between the value of each individual variable, there are key variables which give strengthen to the framework. The majority of these variables advance the governance elements of the Ramplaan, since STSs are always human-facilitated due to the nature of their development. This is, similar like the Ramplaan case, by being a bottom-up (community) initiative that is shaped by groups of enthusiastic individuals creating a more sustainable community. Realizing that the governance related variables show more importance than other variables for the Ramplaan, we took a next step to answer the research question in Chapter 7 by creating a method that facilitated the implementation of these variables in real life. The result is a method that does not only include the modified framework, but also enables the initiators of an ICES like the Ramplaan to have a supporting roadmap that takes them through all the variables to build a proper foundation for an ICES and set-up a stable governance system. The development of the method provides us with the answer to the second sub-question which aimed at finding a way to responding how could we advise the initiators of the Ramplaan case to improve their governance and the adoptions rate of their ICES.

It must be stated that this research has been solemnly based on one case, the Ramplaan Energy Cooperative, so we have no ground to position this method as a general one. However, since most variables allow for a wide spectrum of solutions, we can make the assumption that the modified framework and the methods are valuable for other (emerging) ICESs. Also, our interviews and research outside the topic support this view. Based on our findings we assume, but not claim that if the Ramplaan Cooperative would have looked into the variables in advance and use the designed method to build themselves structure and knowledge on their system and its governance, the process could have resulted as more efficient, faster and comprehensive. We suggest that ICES's advocators or leaders follow a plan or a structure to develop their ICES initiative as mentioned in Chapter 7. Regardless, to consider our developed framework and method widely accepted further trials and analysis is needed on more cases. This tasks could be attained in a follow-up research.

Throughout the analysis we tried to understand why the Ramplaan Cooperative has been successful as it was. We discovered that the cooperative has managed to overcome some barriers that literature does not come to mention. Sabine Jansen explained how displeasing aesthetics appeared to be one of the limiting factors for many inhabitants to consider purchasing solar PV cells for their roof. By placing the solar PV cells on the roof of the Fablo tennis court, this barrier was overcome and the PV cells could be installed at more favourable angle as added benefit. As another example, an important barrier can be the willingness to invest due to a combination of high investment costs and individual effort. The Ramplaan Cooperative board offered a system where the members only had to undertake little action. By becoming an official member, they had to invest in a minimum of two solar power parts, for which the money could be loaned at the Haarlem municipality, and transfer to Qurrent as an energy provider. These were the only steps the member had to undertake, eliminating the pointed out barriers. For the same reason, the Ramplaan Cooperative demotivated inhabitant to invest in their own system, because the alternative, joining the Cooperative, was a much easier option and more economically feasible due to the Postcoderoos policy. This policy does not only decrease the energy taxes and makes the investment economically interesting, it also gives a 15-year security for member on this tax reduction, which offers investment stability. Split-incentives and free-riding also did not apply because of the clear regulation and the contract that was signed by the members. Also, since the electricity production van centrally operated, private interference is not expected. The research has also showed that when more time was spent on the governance and community coordination of the system, where information sharing and engagement was critical, fewer internal conflict arose. Therefore, these two aspects are specifically addressed in the method, to avoid unnecessary confusion of conflict of individuals.

From our background in industrial ecology we proposed a series of tools accompanying the facilitation method. Firstly, we emphasize the need for governance not in the way of a member being asked for participating, but in the way of making partnerships, delegating power and community members taking control. To enable the whole method, we explain that information sharing is probably the most essential variable because it is a trust building. As part of the communication tools that can enhance effective information sharing, we suggest using social norms marketing campaigns. This type of communication campaign promotes a shared mental model, which is highly desirable. In addition to social norms marketing, we suggest that method facilitators should take great care into identifying why a community member would decide to join the project. Besides private benefit, other reasons can be important to build a social identity. We suggest looking into environmental ethics and even sustainable development goals. We show that besides economic performance, other reasons can be used to define productivity indicators, and that productivity could be measure in relation to the shared goal for having an ICES. All of this is part of what we called the soft variables. And we conclude that for ICES development, these variables are as important as technical and economic ones. Probably, they are even more important because they are at the base of building a bottom up collective.

Concerning hard variables, which have to do with technology and institutions for decision making, we explained that based on the community preferences, equilibrium and predictability of the ICES system would have to be defined. This in turn will determine the need for storage and the degree of monitoring more suitable for the system. In the Ramplaan case, since equilibrium in managed outside the system´s boundaries, no choice rules have to be made concerning energy usage by the members. The grid allows for simplicity in the system. However, this fact prevented us from analysing the establishment of rules for a case where energy is a limited resource and community members have to cope with that. Nevertheless, we propose the usage of a grammar of society and a grammar of institutions to consider during facilitation, if needed. Finally, concerning the key variables, we suggest that monitoring and evaluation are given more weight once the ICES is up and running, since performance can only be enhanced by looking at the results from these activities.

Parallel to our social qualitative analysis, we wanted to make some quantifiable prediction that would add value to our findings. Also, this could help to answer our third sub-question that aimed and finding out which constitutional rules were essential to ensure a successful implementation for the Ramplaan case. From the analysis, it appeared that the Postcoderoos policy, especially after extensive lobbying, and the exemption from the Large Consumer connection were critical in the economic feasibility of the system and thus the amount of members interested in investing. To take on this topic we took a modelling approach by setting up a simplified ABM. Within the ABM we verified that both policies influence the adoption of ICES, based in data from the Ramplaan case. Additionally, the model showed that the best investment condition is the tax break through the netting law (Postcoderoos) activated, and connection costs disabled. More specifically, the availability of tax break has greater impact on the business case than exemption from connection costs. This increases the chances of inhabitants becoming a member. Evidently, it must be stated that this ABM was only a simplified set-up and cannot be considered as a representation of a realistic system. However, it does offer some initial insights of inhabitant behaviours and further development of the model can help to quantify predictions when using the key variables identified in chapters 6 and 7.

So the analysis conducted in our report has brought us to several conclusions explaining to what extent and how the variables of Elinor Ostrom's SES framework can be applied to the Ramplaan ICES and potentially other emerging ICESs in the future. What we have discovered is that many variables of the SES framework were suitable for the Ramplaan case as ICES. With several outtakes and modifications, we have adapted the framework to conform to the characteristics of an ICES. Through the development of the modified framework we discovered that governance had a substantially larger role for the development of the Ramplaan Cooperative than other variables and that this would not be apparent if initiators would only use the modified framework. We therefore developed a method that offers a stepwise approach towards the implementation of the Ramplaan case, and potentially other ICESs. Within the method, we propose several tools to enhance the method efficacy. These tools came from our industrial ecology background knowledge. We believe the proposed method is generalizable but special attention should be given to the design phase dealing with decision making. After all our review, we believe the outcomes for the social variables are mostly contingent. We described a series of theories from scientific literature to enhance effective communication and participation, but in the end it is about human relations and there is only so much an ABM can predict. There is still further research required, much more, but if the modified framework and method undergo testing to other ICES cases and are adopted in the ICES implementation process we would have made a contribution to the field. We believe the future for ICESs is bright but needs collective human will.

10 REFLECTION & RECOMMENDATIONS

The following section will provide some reflection on the analysis process and recommendations for further research, going in to more depth on our own work, the decisions and the relevance of potential follow-ups.

When reflecting back on the approach we see that due to the broad definition of what an ICES and the comprehensive SES variables, there was a lot of room to answer the research question. It was, therefore, a good step to narrow down our approach by analysing one specific case within the Netherlands. The Ramplaan case was chosen because it is seen as a successful example of an energy cooperative since it is regarded as a pioneer in the country where the bottom-up approach and the dedication has even lead to national policy changes. The case was very interesting for us to analyse and besides, there was sufficient information available about it.

It was inspiring to see the pride of the Ramplaan Cooperative board member when asking about the success of their ICES. Regardless, there are some notes to be made about the ICES characteristics of the Ramplaan. Although the case was an actual existing example of an ICES, it is still a simple system with only one implemented technology, and thus a meagre ICES. Member of the cooperative were only financial prosumers, for they were not in physical or direct decision-making control of their technology. In terms of grid connectivity and impact, an ICES could alleviate grid dependency dampen fluctuation. The Ramplaan has not yet reached full potential:

- To reach full potential, a higher share of renewable energy is needed than what is used now.
- Only one technology is used. A higher degree of integration requires interaction among available resources, thus different technologies.
- More members are needed to reach full potential. Only 10% of the household participate in this case.

Even so, the community did set up a bottom-up local initiative and expanded it into a real-life working system that allows further development of the ICES. Preparations are currently being made to take future steps by either expanding their cooperative or merging it with other nearby existing energy initiatives. The decision will be made by all members, since each has an equal vote regardless their share of investment. We feel like the Ramplaan case was well chosen, irrespectively of some limitations. It was suitable for a first analysis towards testing the usability of the SES framework for a sociotechnical system such as the Ramplaan ICES.

We aimed at constructing an ABM that could give insight into ICESs' member behaviour. But the fact is that we weren´t able to analyse the establishment of rules and their outcomes within an ICES. In the Ramplaan case members are mostly functioning as investors rather than decision makers. This is not due to the lack of a governance system but because the business model's set-up for the cooperative minimizes the need for members' involvement. It would be interesting to analyse a case where more interactions and outcomes can be used to build an ABM to try and develop more useful predictions. We believe the IAD framework can complement quite well the ABM design and for later research we suggest it is used. Ostrom´s work still holds valuable information for ICES implementation. It could be useful for further analysis to apply her eight design principles. We did not analyse them thoroughly. There is much still to be done in regard to the governance of ICES.

With our approach we created comprehensive analysis of the Ramplaan case and answered the research question. But, since the analysis is based on only one case, we have no ground to make any claims. We can only make assumptions considering the implementation and the applicability of our modified framework and the facilitation method in general. For upcoming ICESs other SES variables could prove to be more useful, as each ICES is unique.

For further research we suggest two options. Firstly, a thorough analysis of many existing other Dutch ICESs to justify our modified framework and methods. This would validate our findings and give the method right of existence. Secondly the method could be tested for numerous emerging ICESs to not only validate its applicability, but to analyse its effects when used and draw conclusions of the key variables for success. Implementing both suggestions would take long, but the results could contribute to what commons researchers claim is still missing in literature, which is the measurement of contextual variables in different communities and contexts.

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12 APPENDIX A: NETLOGO CODE USED FOR AGENT BASED MODEL

12.1 EXPLANATION

This section contains an exact copy of the NetLogo code which was used to build the agent based model. No explanations are included in the code. The model is explained in detail in chapter 7.

12.2 CODE

```
globals [
  ;;;accepted-pbp INACTIVATED FOR NOW TO TEST AS SLIDER
  sunshine-peak-hours
  member-number
  installed-capacity
  year
  electricity-market-price
  electricity-PC-price
  share-price
  share-capacity
  connection-cost
  waiting-list
  receiver
]

;;;globals included as sliders and switches:
;;voluntary-work
;;postcode-regulation
;;large-connection

breed [cooperatives cooperative]
breed [households household]

households-own [awareness household-type member-status expected-pbp]

To setup-globals

  ;;Set accepted-pbp 15 INACTIVATED FOR NOW TO TEST AS SLIDER
  Set sunshine-peak-hours 1500
```

```
  Set electricity-market-price 0.07
  Set electricity-PC-price 0.09
  Set share-price 3400
  Set share-capacity 1
  Set member-number 0
  Set installed-capacity 0
  Set connection-cost 0
End

To setup
   Clear-all
  Reset-ticks
  Set year 0
  setup-globals
  setup-cooperative
  setup-households
end


to setup-cooperative
  create-cooperatives 1
   [
    setxy 0 0
    set shape "house"
    set size 4
    set color 45
      ]
end

to setup-households
  create-households 1000
  ask households [
    set household-type one-of [ "single" "couple" "old" "family" ]
    setxy random-xcor random-ycor
    set shape "house"
```

```
    set color 5
    set member-status 0 ; the idea is to make this variable with one of 3 possibilities: 0, 1 and 2. 0 is not member, 1 is member and 2 is in waiting list - LINKED TO COLOURS: green is member, blue waiting list, gray not member
    set awareness 0
  ]
end

To go-once

tick
  If installed-capacity = 850 [
    Stop]
  Household-actions
  Cooperative-actions
  If large-connection = true [
    Update-connection-cost]
  Set year year + (1 / 12)

End

to go
  if  ticks = 240  [
    Stop]
  If installed-capacity = 850 [
    Stop]
  Household-actions
  Cooperative-actions
  If large-connection = true [
    Update-connection-cost]
  Set year year + (1 / 12)
  set waiting-list count households with [ member-status = 1 ]
  tick
end


To household-actions
```

```
  Update-awareness
  Make-decision
End

To cooperative-actions
  Proceed-membership-and-expansion
End

;;;;things households do: ; Problem now is, that awareness does not play a big role yet. Also, in the formula,
                 ; what happens now is that as soon as a certain payback period is reached, everyone is put on the waiting list.
                 ; The formula given below runs

To update-awareness;;;;; does this make sense? first we create the list 'receiver' with households that fulfill the criteria, then we ask some of them (voluntary-work/2) to update awareness
  set receiver households with [(member-status = 0 and awareness <= 0.2)]
  repeat (voluntary-work / 2)[  ask one-of receiver [ set awareness awareness + 0.2 ] ]



Ask households [
  Set awareness (awareness * 0.8)]
End

;;;;things households do
;To update-awareness;;; THIS CODE I HAD IN MIND FIRST TO UPDATE AWARENESS BUT THE FIRST LINE DOES NOT WORK
 ; Ask n-of voluntary-work / 2 (households witmh ([member-status = 0] and [awareness <= 0.4])) [
  ;  Set awareness awareness + 0.2
   ; ]
;Ask households [
 ; Set awareness (awareness * 0.8)m
;End

;+ income of 1 extra person / total amount of people that joined

To make-decision
  Ask households with  [(member-status = 0)] [
    If post-code-regulation = true and awareness >=  awareness-threshold [
```

```
   Let exp.pbp (share-price + connection-cost) / (sunshine-peak-hours * share-capacity * (0.07 + 0.09 + 0.018))
   If exp.pbp * (1 - awareness) <= accepted-pbp [
    Set member-status 1]]
  If post-code-regulation = false and awareness >=  awareness-threshold [
   Let exp.pbp (share-price + connection-cost) / (sunshine-peak-hours * share-capacity * 0.07)
   If exp.pbp * (1 - awareness) <= accepted-pbp [
    Set member-status 1]]]
End



;; things the cooperative does
To Proceed-membership-and-expansion
If count households with [member-status = 1] >= 5[ Ask n-of 5 households with [member-status = 1] [ Set member-status 2 set color yellow ]  ]
set member-number count households with [ member-status = 2 ]
Set installed-capacity count households with [ member-status = 2 ]
Ask households with [member-status = 1] [Set member-status 0 set color 5 ]



End

To update-connection-cost
 If installed-capacity < 50 [
  Set connection-cost 0]
 If installed-capacity >= 50 and installed-capacity < 85 [
  Set connection-cost 304.57]
 If installed-capacity >= 85 and installed-capacity < 135 [
  Set connection-cost 246.40]
 If installed-capacity >= 135 and installed-capacity < 535 [
  Set connection-cost 64.36]
 If installed-capacity >= 535 and installed-capacity < 850 [
  Set connection-cost 108.06]
End
```

13 APPENDIX B: INTERVIEW RESULTS

Name	Merian Koekkoek
Company	HIER Opgewekt
Website	https://www.hieropgewekt.nl/

HIER Opgewekt:

- There is a lot of information available on energy cooperatives on the website
    - *Dossiers gerealiseerde projecten*
    - *Samen Slagen (history of several field within energy sector)*
- Facilitate knowledge sharing/are information platform
    - Oranize national day sessions (*hei sessie)*
- Have a local energy monitor on their website
- Focus on the need of new energy cooperatives and other stakeholders
- Usually an energy cooperative starts with an idea → project idea → pilot → growth.
    - In the beginning phase all the energy goes to getting the idea off the ground, so usually only at a later stage do people start thinking about the governance.
    - In some energy cooperatives the deliberate choice is made not to cooperate with governmental entities because this could restrict them.
    - Most cooperatives are initiated by the middle aged, technology interested, middle class male (with little communication knowledge)
- Most important stakeholders:
    - Municipality and province policy makers(for licences, ground, roofs, subsidies which are often determined by the level of energy ambitions a municipality has)
    - Companies (such as energy providers)
    - DSO (cooperation is very important with these companies, especially if you are talking about a lot of energy production/consumption)
    - Project facilitating companies (local small to medium businesses for things like installation or maintenance)
- Others (other neighboring energy cooperatives, national branch foundation)

  Barriers
    - Own organization
        - PROBLEM: energy cooperatives exist voluntarily and usually in people their spare time, so there is often a missing working structure
        - PROBLEM: For the real executive work you would have to start paying people for effective work to be done, and this is often not possible due to it being the start of the project
        - SOLUTION: you see now that more and more people are thinking about this and how to set up a hierarchy and figure out a way to include payment.
        - SOLUTION: more structure is needs with less random volunteers and more professionals
    - Volunteers
        - PROBLEM: A problem that occurs is how to arrange some people getting money and others not getting any money.
        - PROBLEM: How do you keep all volunteers engaged
        - SOLUTION: create more working groups
        - SOLUTION: arrange member meetings (or perhaps even digital ones)
    - Communication

        - PROBLEM: Needs a lot of attention otherwise problems occur
        - PROBLEM: Professionals that have a lot of knowledge on the communications are often missing.
- Monitoring
    - HIER Opgewekt has a local energy monitor but that is only aimed at measuring the MW produced (see website)
    - They are thinking of ways how the measure social impact
    - There are some developments in the area of customer relations such as simple software to measure steps taken by members from the start till now (*BENG in de Bilt, Leiden, klimaatbureau)*
- Government role
    - The government has a lot of (smaller) subsidies available for initiatives like this
    - But they also have policies like *regeling verlaagd tarief* especiaaly for energy cooperatives (this results in a win-win for both, because the cooperatives do the work for the government and the government only has to pay)
- DSO (distribution system operator)
    - They know they have to make a transition to a changing and more decentralized infrastructure so are very keen to cooperate with energy cooperative initiatives.
    - Contact with local parties is very important
    - We all have to pay our share to make the transition
- Experiments *regeling van de elektriciteitswet (policy electricity laws)* RVO
    - They are trying to find out what solutions there that will cost the public as little as possible
    - We need to find solutions to decentralized heating through heat pumps because these pumps will create high peaks on the network. DSOs rather have a connected grid so it becomes easier to stabilize all peaks, so communication with other companies is very important.
- Future for energy cooperatives
    - Wind and solar will grow
    - There will be more initiatives and more awareness so there will be more money available with lower margins
    - More companies will join because they feel that they might reach new audiences in doing so
    - New work fields will grow (smart grids, heat storage and usage, etc)
    - Individual thinking and acting will become more important
    - There will be more cooperatives and with the knowledge available more and better copies of the cooperatives will arise
- Totally decentralized?
    - Probably not desirable
    - We do have to start thinking more regionally and collaborate more with DSOs.
    - We will be needing gas to even out the peaks and lows.
    - What you see is that almost all energy cooperatives start with one specific technology (eg solar power in our case), not with multiple technologies.
- Other cases to look at
    - Nijmegen
    - Windpark Krammer (100 MW)
    - Texel
    - Ameland Zonnepark
    - Grunninger Power
    - De A in Apeldoorn
    - Bres Bred
    - U in Utrecht (looking how to include other target audiences*)*

- Zuiderlicht Amsterdam West (focusing in expanding target groups by including for instance lower class citizens *see buurtstroom)*

Name	Sabine Jansen
Company	TUDelft and former member of Stichting DE Ramplaan
Website	

In the very beginning they only had a foundation (Stichting)

Because of it, in 2011 the high level business case was created, paid by the local government.

The municipality is important because it does all the founding- puts all the money.

The Foundation is a group of 11 persons, doing voluntary informal work. In the beginning, the head of the foundation was a very persistent person, like a visionary who really motivated people to take action.

They started by implementing the solar roof, but people were hesitant to participate. Many did not like the idea of having solar panels over their roof because they would look ugly. The decision was made to give the opportunity to use a collective roof, the one from their tennis court.

The Foundation would hold information evenings at the church. Also, they raised lot of interest in the elderly house. They used flyers as well.

People had lots of doubts about investing in the beginning. That's why the information evenings were important, they would explain the mechanism and take worry away.

At the moment, all the people participating get their energy from the cooperative. They get money back, from taxes, by the end of the year.

There were issues with the government business case on collective roofs. The tariff was too expensive (13 cents/kWh), leading to a very long the payback period. Somehow they overcame this problem through lobbying.

Figuring out the collective roof was a good solution because many people were not willing to put the panels on their celling. The contract for the solar roof is 20 years.

Doing more complex projects, like the one related to the sewage system, could bring cobenefits. Right now, a bigger project is starting to be planned, a new vision. The problem somehow is most people are busy, don´t want another thing to deal with more stuff.

Their project on the new vision is planned to be finished by 2018.

They began new communication activities. For example, an energy battle at the primary school, with kids. Beginning to think of new target groups.

Possibly, they need a communication and participation plan. They also need options to offer to people.

In the neighborhood they feel like in an island. The space is a limitation (can really be a challenge), and also the age of the houses. Aesthetics play a role, because most people do not find the solar panels to be beautiful on their roofs.

About monitoring: energy production is easy to measure, but that is about it.

The impact of the foundation or the cooperative has not been researched yet.

For the implementation of the roof project, five persons worked for a complete year 8 h per week. This is unpaid work.

Now, their ambition seems to be focused on going not off the electricity grid, but off the gas grid.

Her questions:

- Is decentralization the right way to go?
- What is the role of communities?

Name	Eise Jan Wattel
Company	Cooperatie DE
Website	http://deramplaan.nl/

DE Ramplaan Cooperation

- Function
  - He is the chairman of a 5 member board, all with their own expertise
  - All voluntary
  - Have put a lot of effort in having the right combination of expertise (financial, communicative, technical)
  - In the beginning it took them each about 6-8 hours a week, but now it only takes about 1 hour a week
- The municipality of Haarlem wants to be energy neutral in 2030 so they have been very supportive
  - The board has had many conversations with the municipality
  - Ramplaan is a very appropriate area for this because:
    - Mainly middle aged, upper class, white families
    - Nice green area with clear boundaries
    - Have a big tennis hall with large roof area nearby
- The plan was initiated by the Stichting (the goal of the stichting was make the whole area sustainable, solar pv was one of them), which was set up in 2011. In 2014 they wanted to find people interested to be in the board of a new initiative: the cooperation.
  - The high level business plan was the starting point
  - They started with meetings in the old church to get people to sign up their email address. This email address turned out to be very important because it created some sort of community and easy reach out.
- How does a membership work?
  - From jan – march 2014 they flyered a lot and had a stand every Saturday where people could sign up.
  - You signed up by buying solar power parts (one part was equal to 250 kWh per year and cost €325-350) The payback period was at that time still unknown, but turned out to be 10-15 years.
  - You are a formal contract with the cooperative but both also have one with Qurrent (the cooperation has arranged discounts for the members with Qurrent)
- Size of cooperation
  - 1609 solar power parts
  - 1349 panels
  - 220 members
    - They are currently not actively trying to get more members
  - Newsletter every 6-7 weeks
  - They are facilitating that people can re-sell their solar power parts of new owner are found when somebody passes away
  - They are the largest postcode roos in the country (google how it works exactly)
- Reason for joining
  - Sustainability was found important
  - Community feeling, it was very close by

    - The cooperation made being sustainable very easy (you only had to pay money and change energy provider)
- Making decisions
    - They have set up statutes and have a board of commissioner (and all other things a foundation has to do by law)
    - The important choices are made by the members
    - Each member has an equal vote, regardless of the investment made
- Barriers
    - Getting people to join/engagement
    - Getting legal rights/insurances
    - Postcode roos was not financially interesting in the beginning
    - Finding time and energy to get enough members
    - Getting all parties aligned
    - Grootverbruikers regeling
    - How do you handle external factors such as damages/the weather etc
        - There is a lot of communication and trust necessary
        - There we no significant internal conflicts
        - The administration was a lot of work (ICT, changed in membership, fiscal)
- Future
    - Join with other initiatives in Haarlem such as Kennemer energy
    - Bundling existing initiatives to get more solar panels on different roofs such as the library
    - There is now a communication plan that has to help with the next steps
        - Next step in insulating houses (but then you need the whole area, not just a couple of houses)
    - The main goal was to get the system up and running, which they have now.
    - The next step is to discuss what they want in the future
        - He proposed to sell the cooperative to Kennemer Energy.
    - Future of energy sector:
        - More and more will become local and off grid
        - There will be storage everywhere
- Most important stakeholder
    - Firma tool (from the roof)
    - Members
    - Energy providers
    - Municipality
    - DSO (alliander)
    - Tax company
    - Installation and delivery solar panels
    - Insurance companies
    - Other NGO's (such as HIER Opgewekt, other cooperatives)
    - 2e kamer
- What is essential for a cooperative to work:
    - Enough expertise
        - Analytical power
        - Communication skills
        - Financial knowledge
        - Thinkers and do'ers
    - Building on existing knowledge
    - You have to find the right people

- Bottom up working, involving the community