Developing Responsible Innovation Systems

the case of the rural energy sector in India

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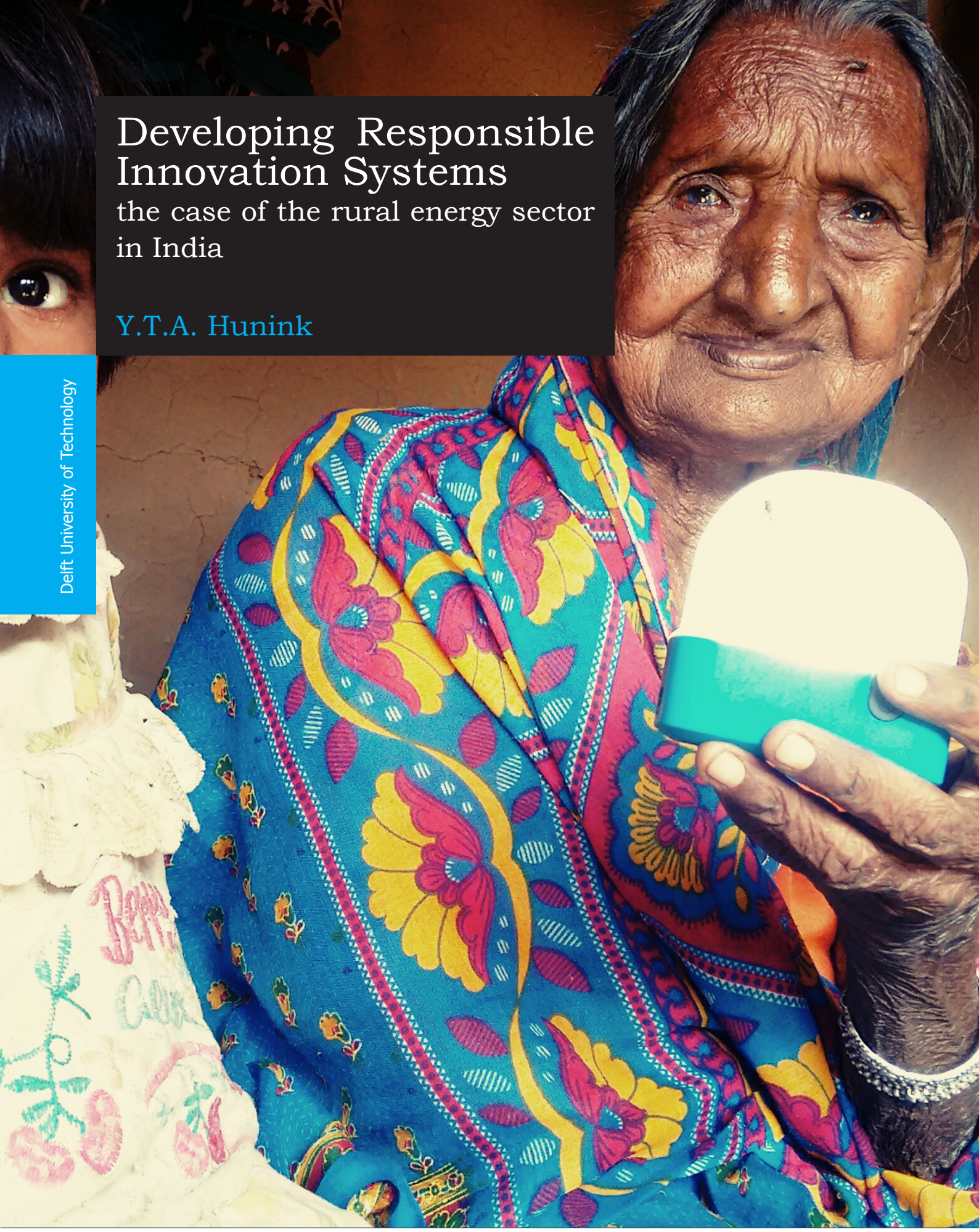

TU Delft Delft University of Technology

Challenge the future

Developing Responsible Innovation Systems

the case of the rural energy sector in India

by

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Preface

Like the body that is made up of different limbs and organs, all mortal creatures exist depending upon one another. - Indian Proverb

During the kick-off meeting of this project, professor Van Beers wondered what kind of student I was, since he couldn't place me at the faculty of Technology, Policy and Management. Therefore, it urges me to explain my reader, what the building blocks that helped me to complete my master thesis.

I managed to finish a bachelor mechanical engineering, but I never loved it. However, during the minor programme International Entrepreneurship and Development, I got the chance of travelling with a group of three friends to The Gambia for three months. We created a solar dryer, able to dry fruit, so that their period of hunger could be reduced. Here I started to see what the world was doing and becoming and what the role was that I could and should take in it. Esther Blom as my supervisor, from the Delft Centre of Entrepreneurship and part of the minor, represents the first building block of my motivation.

Sustainable energy technology (SET) quickly became my greatest interest and I decided to make that the topic of my master programme. During the lessons in the first year, I came across the concept of innovation systems for the first time. It struck me, while relating these to the rest of the classes, that our world possesses nearly all the technology required to change to a sustainable globe. The only thing preventing it from happening is the slow reorganisation of our own societies, governments, industries and universities. Linda Kamp, from the faculty of Technology, Policy and Management and head of the Energy & Society track within the SET master, represents the second building block of my motivation.

Impact is a key word in development. The country of India, with the mysteries of 1.3 billion people, many of which needing to come out of poverty, is where impact is going to happen. With the help of Esther, I found Rural Spark. It is a brave company led by three Dutch guys and operating in India, where it aims to create bottom up energy systems. With Linda as my supervisor, I was able to do an internship for Rural Spark on exposing the barriers for microgrid implementation in rural India, representing the last building block that got me in the starting position for the final task ahead.
Ultimately, the process of designing a master thesis began and the three building blocks came together. Esther, Linda and Rural Spark accepted me and my thesis proposal, allowing me to spend 3 months in India, where I lost a passport, but gained a lifetime of experiences.

I would like to all of them for their believe in me. I also sincerely want to thank my parents and my other loved ones for giving me their undying support and joy during the complete length of my period as a student in Delft. Lastly, the participants of this research for their time and helping me to deliver you as a reader... the journey through the Indian rural energy technology sector for developing responsible innovation systems.

Y.T.A. Hunink
Delft, September 18th 2017

Made possible by contributions of:

Figure 1: All organisations that filled out questionnaires and/or allowed field visits, with special notice of Rural Spark as project facilitator.

Abbreviations

- CERC - Central Electricity Regulatory Committee
- CSR - Corporate Social Responsibility
- DISCOM - Distribution Company
- DDUGJY - Deen Dayal Upadhyay Gram Jyoti Yojana (policy scheme)
- ERC - Energy Regulatory Committee
- ESCO - Energy Service Company
- FIS - Functions of Innovation Systems
- GIPU - Government-Industry-Public-University
- GoI - Government of India
- IIT - Indian Institute of Technology
- INR - Indian Rupee
- MBA - Master Business Administration
- MNRE - Ministry of New and Renewable Energy
- MoP - Ministry of Power
- NGO - Non-Governmental Organisation
- NIT - National Institute of Technology
- OI - Open Innovation
- REC - Rural Electrification Corporation
- REDA - Renewable Energy Development Agency
- RI - Responsible Innovation
- RIS - Regional Innovation Systems
- SHS/SHL - Solar Home System / Solar Home Lightning
- SI - Systems of Innovation
- SME - Small or Medium Enterprise
- SNA - State Nodal Agencies
- SERC - State Electricity Regulatory Committee
- TH - Triple Helix
- THS - Triple Helix Systems
- UP - The State of Uttar Pradesh
- VEC - Village Energy Committee
- 4H - Quadruple Helix
- 5H - Quintuple Helix

Glossary

- **Absorptive capacity** - A firm's ability to recognise the value of new information, assimilate it, and apply it to commercial ends.
- **Civil society** - Aggregate of non-governmental organisations and institutions that manifest interests and will of citizens
- **Collective innovation process** - The combination of all processes that contribute to the development of a certain focus area, distributed among different actors.
- **Economic capital** - Nation's current production of valued goods and services plus its capacity to produce them in future. It includes intellectual capital with financial capital to indicate the total productive capital of a society.
- **Energy poverty** - A lack of access to modern energy services
- **Ex-ante characteristic**s - 'Before the event' characteristics of firms that are determinants for their further development from the point they enter in the market.
- **Human capital** - Intangible collective resources possessed by individuals and groups within a given population, including knowledge, talents, skills, abilities, experience, intelligence, training, judgment, and wisdom possessed individually and collectively, the cumulative total of which represents a form of wealth available to nations and organisations to accomplish their goals.
- **Interactive learning** - Interactive learning is defined as the acquisition of knowledge and competences through interactive collaboration with firms and knowledge providers. Innovation is the result of an interactive learning process stretching across firm borders.
- **Innovation system** - All important economic, social, political, organisational, and other factors that influence the development, diffusion and use of innovations
- **Institutions** - Rule-structures that behave as formalised societal contexts, acting as selection mechanisms for innovation, such as academia, governments, industries and civil society
- **Collective irresponsibility** - A virtual space, where there exist no accountability structures to guide collaborations to prevent conflicts between institutions
- **Intermediary/Hybrid/multi-sphere organisation** - Organisation that operates in more than one institutional arrangement
- **Knowledge types/capital** - Defined as the different knowledge that institutions produce, conceptualised in political, economic, social and human capital.
- **Laissez-faire** - An economic system in which transactions are free from government interference such as regulations, privileges, tariffs, and subsidies. Translates from French in 'To let go'.
- **Open Innovation** - A distributed innovation process based on purposely managed knowledge flows across organisational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organisation's business model.
- **Political capital** - Political assets, public strength or political influence.
- **Responsible Innovation** - taking care of the future through collective stewardship of science and innovation in the present, by applying the dimensions of anticipation, reflection, inclusion and responsiveness

- **Responsible innovation system** - An open knowledge network that allows for the Quadruple Helix to emerge and the regional innovation system to develop, while the dimensions of anticipation, reflection, inclusion and responsiveness are internally and mutually shared among the actors
- **Rural energy technology** - Combination of technologies that facilitate energy access in rural areas through small charging, solar home lightning, solar home systems and all scales of grids.
- **Social capital** - social capital is an instantiated informal norm that promotes cooperation between two or more individuals

Figure 2: A representation of the words that appear the most frequently throughout the report

Abstract

Technologies used in the energy sector, and many other sectors, are too complex for innovation by a single actor. Many influences from different types of actors are required to advance the technology, creating a collective innovation process. However, without the right accountability structures between different types of actors, unfavourable outcomes might emerge as the result of collective irresponsibility. Responsible Innovation is a theory that aims to improve the degree of responsibility of innovation processes, by incorporating the dimensions of anticipation, inclusion, reflexivity and responsiveness in the innovation process. However, to date this has been mostly applied to individual organisations. No framework exists that can assess and guide the responsibility of the collective innovation process of an entire system of actors. The objective of this exploratory research is to create a first version of a framework that can do such and perform an initial case study to generate insights for its future use.

From a literature review, responsible innovation in the collective innovation process was specified as the application of the intertwining dimensions of anticipation, reflexivity, inclusion and responsiveness in an evolutionary environment with actors of an innovation system that contains a constant group of institutions, while an open knowledge environment is present. Three concepts helped to define what a responsible innovation system is. Systems of Innovation helped to determine that innovation systems emerge on a regional level. The Quadruple Helix helped with the categorisation of the active institutions (Government, Industry, Academia, Civil Society) and the evolutionary characteristics of a system. Open Innovation helped to determine what an open knowledge environment entails in innovation. A responsible innovation system is then defined as an open knowledge network that allows for both emergence and evolution of the four institutions of the Quadruple Helix and the regional innovation system to develop, while the dimensions of anticipation, reflexivity, inclusion and responsiveness are mutually shared among the actors. A combined framework was constructed consisting of three elements: components, relations and functions. In the components, the actors are characterised according to the Quadruple Helix and the system is evaluated on its inclusion of all institutions. In the relations, two-way knowledge channels are revealed, with the help of Open Innovation. In the functions the three virtual spaces of Knowledge, Innovation and Consensus are created, each with its specific role of explaining interaction in the system. The Consensus Space will only form if the dimensions of anticipation, reflexivity and responsiveness are found in the activities within and among the actors of the system. Also a number of conditions for a responsible innovation system to emerge were set up.

The framework is subsequently applied to the case of the Indian innovation system of rural energy technology, after an institutional analysis showed that all of the institutions are present and active in the system. The framework was applied in three data collection methods, which covered different parts of the collective innovation process, explained as the exploration, construction and implementation phases. Several local event visits showed that in the exploration phase has arenas exist where responsibility prevails, but governmental policy feedback events are far from inclusive, anticipatory and responsive. Structured interviews with 17 organisations, predominantly actors from industry and civil society, reveal that in the construction phase, inclusion of governmental and academic partners is limited. Also two-way communication channels were often absent, preventing alignment of goals and values through anticipation, reflexivity and responsiveness in the Consensus Space. From the actor analysis, CLEAN appeared to be the most central actor of the system. Semi-structured interviews with end-users showed that full inclusion is also absent in the implementation phase, while also responsiveness should be increased. The framework appeared to succeed in revealing the important interactions of an innovation system, because it became clear that government and academic actors are not sufficiently included in the innovation activities of the industry and civil society institutions, further preventing alignment of objectives in order to achieve responsible innovations. Evaluation of the conditions showed that these indeed left some gaps to be filled. Overall, the results show that actors in the system should perform more co-creation activities between institutions.

It should be noted that a validation of the results generated several limitations to the research and the framework, leading to recommendations for further research. It was shown that due to multiple realities in the intersections of an innovation system, the results of the framework can not always be generalised and needs to have input from central actors of all institutions. Also, the way a component or relation contributes to anticipation, reflexivity and responsiveness should be revised, because the framework fails to capture gradations in such contribution. Next to that, the oversimplification of the characterisation of actors might prevent a good evaluation of the system. Furthermore, there appears to be a tension between effectiveness of the activities of organisations and responsibility, due to the large amount of resources that are needed. This means that to become responsible might take more time and effort, making the activities less efficient in reaching the objectives. This would make the framework more usable for the exploration phase, opposed to the other two phases, because in this phase the goal is generally to have a broad perspective, while in the construction and implementation phases a certain focus is required and intervention of many stakeholders might trouble the process. Also, the conditions of the framework should be further examined and enhanced, possibly with a role for CLEAN as the central actor. Lastly, in line with global issues, the framework could be extended with the Quintuple Helix with the environment as additional institution, so that innovation systems might also be in line with ecological constraints. Also, among some other operational limitations, the research failed to question all institutions, creating a potential bias in the results.

More research is needed to validate the framework and the results, both within and outside of India. Still, a first exploratory step has been taken towards a framework for assessing and guiding towards responsible innovation systems.

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Introduction

India is a country of many faces, parallel to the many gods that are portrayed throughout the extensive religious storytelling that is told. In 2020, India is expected to be the largest country in terms of inhabitants and these people will be in need of food, water, shelter and energy. India is already the third-largest economy in the world in terms of purchasing power parity with one of the fastest growing service sectors. (International Monetary Fund, 2016) It happens to be that increasing wealth is causally connected with an increasing demand for electricity in developing countries. (Wolde-Rufael, 2006) To date, however, still 244 million people in rural India are waiting to receive a connection to a reliable source of power, as observed by the International Energy Agency (2016a). The Government of India (GoI) acknowledges the need of electrifying the country and has started a movement in the direction of electrification, by intensively reforming the electricity sector. The past decades of reform have proven encouraging for the electricity generation segment, however, the segments of electricity transmission and distribution are lagging behind in development as was found by Hunink (2016) who defined the main barriers to implementation of rural microgrids in India. He revealed technological, economical and institutional barriers that still obstruct the increase of access to energy for rural communities. Some of the findings have served as the base for the problem definition in this thesis.

Figure 1.1 shows the transformation a village would undergo from not having access to energy to being electrified. A transformation that cannot happen overnight. To make the change there is need of political, economic, social and human capital. In the transformation process, therefore, many stakeholders are required to contribute, such as policy makers, technology partners, civil society actors and educational institutes. The complexity of energy technology in itself already requires innovation in many different technological disciplines, such as electrical engineering, information technology, chemical engineering and so forth. Furthermore, the inclusion of the technology in society, economy and environment will require sociological, political, economical and ecological insights. It is clear that implementation of rural energy technology is one with many sides.

Evidently, organisations need to participate in collaborations to progress in the development of rural energy technology. Collaborations with academia to provide research data and develop innovative technologies, with governments to create new policies and regulations, with industry to create new business models and local production sites and with communities to create support for the technology that will influence their lives, as they are soon able to generate their own energy and become so-called prosumers (from producers and consumers). It will create a system of actors and interactions that are collectively trying to implement rural energy technology, which requires a good deal of innovation in products and services to overcome the challenges that are being faced.

Innovation in this system should be regarded as a shared responsibility between the actors that collectively contribute to it. (Von Schomberg, 2007) Interactions between actors do not only help create this system and evolve it, but can also pose risks that have to be addressed. (Hellström, 2003) Such a collective nature of the innovation process makes it unpredictable and difficult to control. While individual actors might not have malicious intentions, the complex system of innovation can lead to unfavourable outcomes, of which afterwards the responsible entity is difficult to determine, because of entangled activities and complex cause and effect dynamics. This is called 'organised irresponsibility'

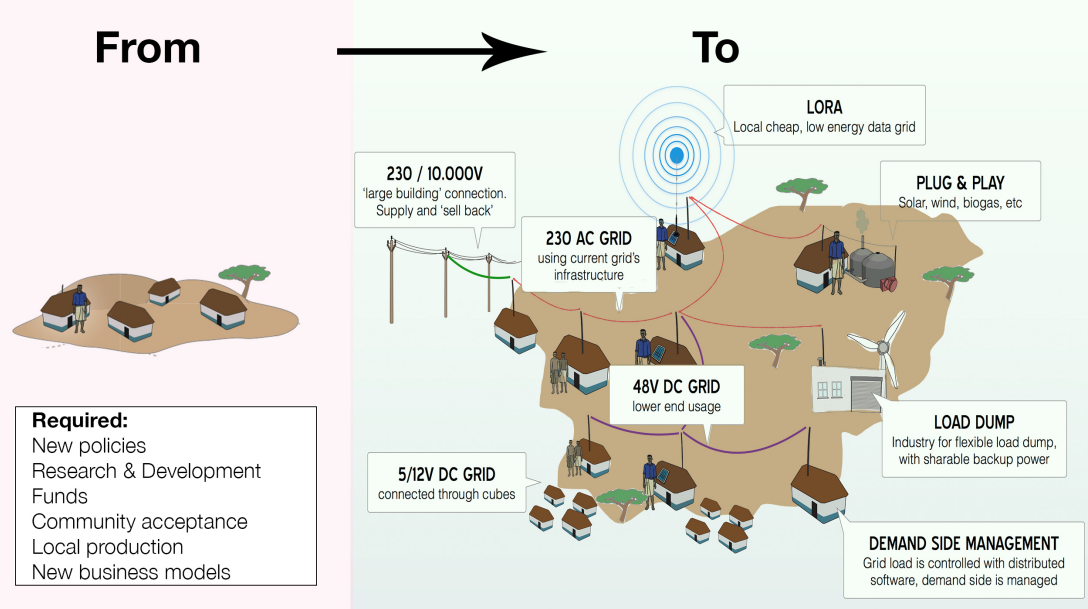


Figure 1.1: Transformation of village led by ESCOs

and poses as a real risk if the activities of all actors are not appropriately aligned and evaluated. (Adam et al., 2000) The example of nuclear technology illustrates this. At first, nuclear technology was introduced as the solution to global energy problems, but harm it would later do to humanity was not accounted for by the researchers of the technology. Therefore, there should be a framework in place that can guide the collective innovation process towards a more organised responsible approach, reducing the risk of unfavourable outcomes that cannot be accounted for. The following quote of Edward O. Wilson, the 'father of biodiversity', presents the status quo of our societies: *"We have created a Star Wars civilization, with Stone Age emotions, medieval institutions, and godlike technology. "*

A method introduced by Stilgoe, Owen and Macnaghten, with the fortunate name of Responsible Innovation (RI), is a framework that looks at responsibility in innovation processes. (Stilgoe et al., 2013) It promotes to follow the dimensions of Anticipation, Reflexivity, Inclusion and Responsiveness in technological development and innovation. Responsible innovation, in their words, means taking care of the future through collective stewardship of science and innovation in the present. While this is a broad statement, the dimensions can serve as guidelines and design requirements for today's decisions. RI works as a filter to remove innovation processes that might lead to a collective irresponsible situation, not only changing technologies but also institutions that are in the decision making process of design choices. The scholars provide several tools that will help to include one or more of the dimensions from the beginning of the design process in an organisation.

However, in the current literature, RI is mostly applied to the innovation processes of single organisations and their direct relations. **Not yet has a framework been developed that sees to responsible behaviour of an entire innovation system of actors.** This research aims to bridge that gap in the responsible innovation literature by going on an exploratory quest to create a new framework. With the framework, it should be possible to determine what degree of responsibility complete innovation systems have and how they can be guided to reach a higher degree of responsibility, by showing the gaps in their activities. The framework should serve for different configurations of innovation systems in different sectors, locations or in time. In order to achieve this, it is important to expose what the current theoretical views are on innovation systems with the components, relations and functions within it and how these can be connected with the Responsible Innovation framework in order to make a Responsible Innovation Systems framework.

Several characteristics are required to be conceptualised for a meaningful purpose of this research. The specific actors that are involved with the development of rural energy technology in India need to be uncovered and how they relate to each other. What must further be noted is that the actors are part

of different institutional contexts and must be accordingly described as such. Institutions are defined as rule-structures that behave as formalised societal contexts, such as academia, governments, industries (Pesch, 2014) and arguably, civil society. (Carayannis and Rakhmatullin, 2014) It can be expected that different knowledge types are created and transferred across the institutional boundaries, which need to be permeable in order to do that.

Several theories, namely Systems of Innovation (SI), Triple/Quadruple Helix (TH/4H) and Open Innovation (OI), are discussed for their accordance to meet these requirements and a combined approach will be sought that makes use of the characteristics of those tools and the RI framework. This should create a first version of a new framework for the analysis of the collective innovation process, which is segmented in an exploration, construction and implementation phase for a better evaluation. The constructed Responsible Innovation Systems framework will be applied in a comparative case-study in the Indian rural energy technology sector, where data will be collected through qualitative research in the form of three different data collection methods corresponding with the three phases, covering several stakeholders and determining their responsibility. A number of event visits will generate observations for the exploration phase. A structured interview with organisations gives insights in the construction phase. Lastly, semi-structured interviews with end-users during field visits in the rural areas generate data for the implementation phase,

While the created framework serves an academic purpose, the research serves an important societal purpose too. The sustainable development goals (SGDs) of the UN, can be used determine which contributions to society are done. In Figure 1.2 the SDGs that this research can contribute to are represented. (United Nations, 2016) There are several reason why this research will contribute to those goals. The framework can be used to assess the current system, but should also guide future activities to be more robust and responsible. The framework will help the different institutions in their innovation processes and create the right infrastructure for innovation to thrive in a sustainable environment and make production and consumption more responsible, because the right partnerships and stakeholders are included. If successful, the framework will accelerate robust innovations that are able to sustain, because of accordance of all stakeholders. Electrification, and therefore the wealth of the community, will inevitably speed up because of this strengthened innovation environment. Since distributed renewable energy resources are currently economically more interesting then fossil fuels (Comello et al., 2017), the newly installed energy will also be clean, serving a environmental purpose as well.

When researching responsible contributions to innovation, there is a strong moral obligation to make this thesis a responsible contribution in itself as well. The four dimensions of RI should therefore also be enhanced by the deliverable of this thesis. It should include all relevant institutions, their goals, desires and values, anticipate on future events, reflect on divisions of roles in the system and create resources for a swift response in changing situations.

Summarising, the **main objective of this exploratory thesis** is to create a framework for assessment and guidance towards a responsible innovation system, while generating initial insights with a case study in India. It is necessary to define what it means to have a systemic responsible innovation process, being the subject of Chapter 3. Furthermore, the framework needs to be constructed from theories that comply with the required characteristics, done in Chapter 4. An initial case study performed in India shall try to expose systemic RI elements through use of that framework, shown in Chapter 6 and 7, helping to create the first insights of what such a framework might help to do. Then, the research needs to be evaluated for threats to validity, evaluated in Chapter 8. Finally, the limitations caused by threats to validity are noted and used to create clear recommendations for further research, while also some recommendations for the system to become more responsible can be noted with the initial results from the case study, holding the research to its own ethical guideline, after which the research in concluded, all in Chapter 9. All together, this has resulted in the research questions in Table 1.1

Table 1.1: The research questions, together with the type and the chapter in which the question is answered

Type	Ch.	Question
Main	**9**	**How can a framework assess and guide the responsibility of the collective innovation process in innovation systems?**
sub	3	*What is a responsible innovation system?*
sub	4	*What framework can be constructed to expose responsible innovation practices on a systemic level?*
sub	5	*What are the characteristics of institutions influencing innovation in the Indian rural energy technology sector?*
sub	6/7	*In what way can an initial case study with the framework show responsible innovation characteristics in the rural energy technology sector of India?*
sub	8	*What are the threats to internal and external validity of the research and what does this imply for further research?*

Figure 1.2: Sustainable Development Goals to which this research has the potential to contribute (United Nations, 2016)

2

Methodology

Every research question as mentioned in Table 1.1 will use an appropriate methodology to be able to answer the question in a coherent way. It also allows the research to be replicated by others in order to test the outcomes and conclusions. The combination of methodologies for the sub questions is used to answer the main research question, which reads: *How can a framework assess and guide the responsibility of the collective innovation process in innovation systems?*

What is a responsible innovation system?

This sub question can be divided in two separate parts and is answered in Chapter 3. 'What is responsible innovation?' and 'What is an innovation system?'. Both are answered by a literature study in The Netherlands.

What is responsible innovation? - The framework as proposed by Stilgoe, Owen, and Macnaghten (2013) draws the lines on which responsible innovation (RI) will be defined. Through a careful reading of their work, the different aspects have been set out of how responsibility in innovation can be approached. In addition to this, a selection was made of the literature that either cited their figurehead paper or has been cited in their work. In this selection, the papers that focused on RI in organisations and emerging countries were taken to be of relevance. Literature on RI in innovation systems was not discovered, exposing the gap in the literature that needs to be bridged.

What is an innovation system? - Innovation theory is a widely researched topic, where the theory on innovation systems in itself is merely a part. There was an extensive collection of relevant literature available previous to the start of the thesis. The work in this thesis is not confined to one paradigm of innovation theory. Much of the literature used, therefore, is not based on a systemic approach that would be looking for all available research in such a paradigm. It has rather derived from an extensive read through multiple paradigms of knowledge and innovation, where potential building blocks for responsible innovation systems were selected upon discovery. The pathway of that reading is shown through a historical view on innovation in Appendix A. During this extensive read, a selection has been made of the branches of innovation and knowledge theories that were found applicable, with the condition of being able to apply it in complex knowledge networks. The theories that were discovered not to be applicable are also mentioned in Chapter 3

The core theories that have been derived this way are Systems of Innovation, Triple Helix, Quadruple Helix and Open Innovation. These terms were searched independently and cross-combined, also with the terms 'responsible innovation', 'India', 'developing countries' and 'rural development' in the scientific search engines of Google Scholar and Scopus, where relevant research papers were selected. Also, journals of Responsible Innovation and Triple Helix were consulted. The combination of those terms was chosen, because this way literature could be found that discussed potential combinations of such theories, especially for use in the context of India.

What framework can be constructed to expose responsible innovation practices on a systemic level?

From the results that appeared by answering the first sub question, relevant innovation theories were considered for use in a responsible innovation system framework, constructed in Chapter 4. Again, a literature study is performed, after which all advantages and disadvantages of the specific theories are weighed. An additional input was retrieved by meeting innovation expert Patrick Van Der Duin from The Netherlands Study Centre for Technology Trends, where the inputs for such a framework were discussed. Since the previous knowledge on innovation systems of the writer could be considered new-made, this helped to gain additional feedback.

Through a careful analysis of use cases and critiques of the theories, a combination is sought in order to address the specific needs of a complex modern knowledge and innovation system, being an components divided in institutions, relations with knowledge transfer crossing the (semi) open boundaries and a clear set of functions of what a responsible innovation system should do. Responsble Innovation, Systems of Innovation, Triple Helix, Quadruple Helix and Open Innovation are used because these theories addressed those specific needs. A sub combination of SI and TH was found in Triple Helix Systems, by Ranga and Etzkowitz (2013). This framework was used as the main building block for a further combination, because of the concrete steps it proposes for analysing an innovating system. A Responsible Innovation Systems framework emerged from this initial building block, by adding the remaining theories into the synthesis.

What are the characteristics of institutions influencing innovation in the Indian rural energy technology sector?

First, it will be determined how rural energy technology is defined. Then, from the constructed framework, for each of the institutions of the quadruple helix, namely government, industry, public/civil society and university, the contextual factors were determined. The contributions of each institution to rural energy technology is presented, since this will serve to a better design of the case study and addition observations in a later stadium. All of this was done through a literature study.

The government institution is analysed on relevant policies and regulations that govern the development and operation of rural energy technology. Also, the relevant governmental bodies that instigate these policies are presented. The industry sector is analysed on the companies that create business models and economic capital around the technology. It appears that many companies in the field are social enterprises, acting on the intersection of industry and civil society. The sphere of civil society is further examined by a demographic analysis of the population and its access to energy. Lastly, the educational system of India is addressed, exposing relevant universities and research institutions.

In what way can an initial case study with the framework show responsible innovation characteristics in the rural energy technology sector of India?

During a 3-month visit to India a number of different data collection methods have been applied in order to find initial insights for use of the framework. The moral obligation explained in the introduction requires the research itself to be of a responsible nature, therefore requiring the data collection to be of an inclusive nature, creating results that can be used for anticipation and reflexivity, while creating a larger responsiveness to changing situations. Therefore, it is required to include all relevant institutions in the research, which was the focus during recruitment of participants. Furthermore, during approaching, convincing and interviewing potential participants for the research, a communication strategy was created through an exercise of creating a socio-technical value map, which can be found in Appendix B.

The collective innovation process is a complex set of dynamics, consisting of elements such as the search for new ideas, the design and production of solutions and the roll-out of products to end users. It is used that an innovation process can be simplified and reduced to three main phases, namely exploration, construction and implementation. To assess responsibility of the entire process, a different data collection method needs to be used for each phase, respectively, being event visits, a structured interview with organisations and a semi-structured interview with end users. Each phase is then held against the constructed framework, in order to assess the elements required for responsibility.

For the exploration phase, a number of events were attended that in some way related to energy

access for the rural poor, namely India Smart Grid Week, ICEGOV2017 Digital India, WWF Climate Solver and a public hearing for policy feedback of the Central Electricity Regulatory Committee. Also, because of the unwillingness of governmental organisation to participate with the structured interview, the event visits have served to be an additional data input from the perspective of the government institution.

The structured interviews for the construction phase are meant for organisations from any of the institutional spheres, so that the full innovation system can be assessed. When one thinks about rural, one thinks about bottom-up or frugal innovation. Finding relevant actors in the system was also approached from bottom-up. Suppliers of rural energy technology products that directly come in contact with the people in rural villages were targeted for the initial exploration of the system, instead of, for example, more top-down governments or universities. It appeared that this was at the intersection of industry and civil society, because the found organisations are all social enterprises. With terms relating to rural energy technology as keywords, combined with India, it was tried to locate social enterprises through an online search. Relevant organisations were contacted and asked to participate in the research. This is partly done in The Netherlands and during the time in India.

From the discovered networks of the social enterprises and their relations, a second iteration was done where other relevant players with an important role in the system were approached, all actors of an intermediary nature. With a total of 17 willing participants, the interviews were held, with a questionnaire that asks for several ex-ante characteristics, relationships to partners and RI dimensions. Rural Spark, which helped facilitate this research, was used as a pilot case to determine the quality of the questionnaire, after which a improvement of the questionnaire could be done. If possible the interviews were done in person, but due to long distances within the country, this was not always an option. Therefore, an online questionnaire, with a clear drop down menu of options wherever possible, has been set up. The questionnaire was always combined with a telephone call to explain the research in detail, in case no meeting could be arranged. Some of the empirical evidence is presented in the form of visualisations through a network model programme called Gephi.

For the implementation phase, the semi-structured interviews have been performed in the most energy poor areas of India, namely Bihar and Uttar Pradesh. Open discussions were held, where the content of the discussion could gently be steered according to the relevant subjects for those cases. Different projects with rural energy technologies are examined for accordance to the framework from the perspective of the end users. All field visits were done with an interpreter that was informed of the meaning of the research and could sense which direction the conversation had to be taken.

The combination of data collections will expose an intersection of the rural energy technology innovation system and assess its responsibility throughout the phases of the collective innovation process. It lays ground for a clear assessment of the participants of the research and their relations, creating possibilities for reflection of their roles in the system. It will also generate future visions on how a responsible innovation system is going to emerge, allowing them to respond by designing their activities for such a system according to the knowledge created by this particular research.

What are the threats to internal and external validity of the research and what does this imply for further research?

Until today, validation and generalisation of qualitative research is an open discussion. Although qualitative data can be used as scientific evidence, it must be governed by clear criteria that can monitor and assess the robustness and quality of the findings. (Madill et al., 2000) In order to construct and assess those criteria a framework was designed by two scholars that addressed this from a 'threat to internal and external credibility' perspective, which can be seen in Figure 8.1 of Chapter 8. (Onwuegbuzie and Leech, 2007) From these threats, the criteria are derived that evaluate if a valid result was obtained and how it can be generalised. In the paper accompanying the introduction of their 'Qualitative Legitimation Model' the scholars speak of the broad use of this model, however do not claim it to be a single truth, leaving room for changes. Part of the validation is seeking the relevance of the model and applying it to the case at hand. This led to the addition of a validity that relates to integrity, derived from observations during the case study.

Flowchart

As a way of summarising, this chapter is captured in the flowchart that shows the methodology of this research project visually. Figure 2.1 helps the reader with colours, where blue and purple signify, respectively, work done in The Netherlands and India. Furthermore, several arrows are feedback lines, where iteration processes take place. The answers to all the sub questions, with their respective methodologies, will lead to answering the main question of 'How can a framework assess and guide the responsibility of the collective innovation process in innovation systems?'. And as is common in scientific work, one starts with diving into the literature, that Chapter 3 will present.

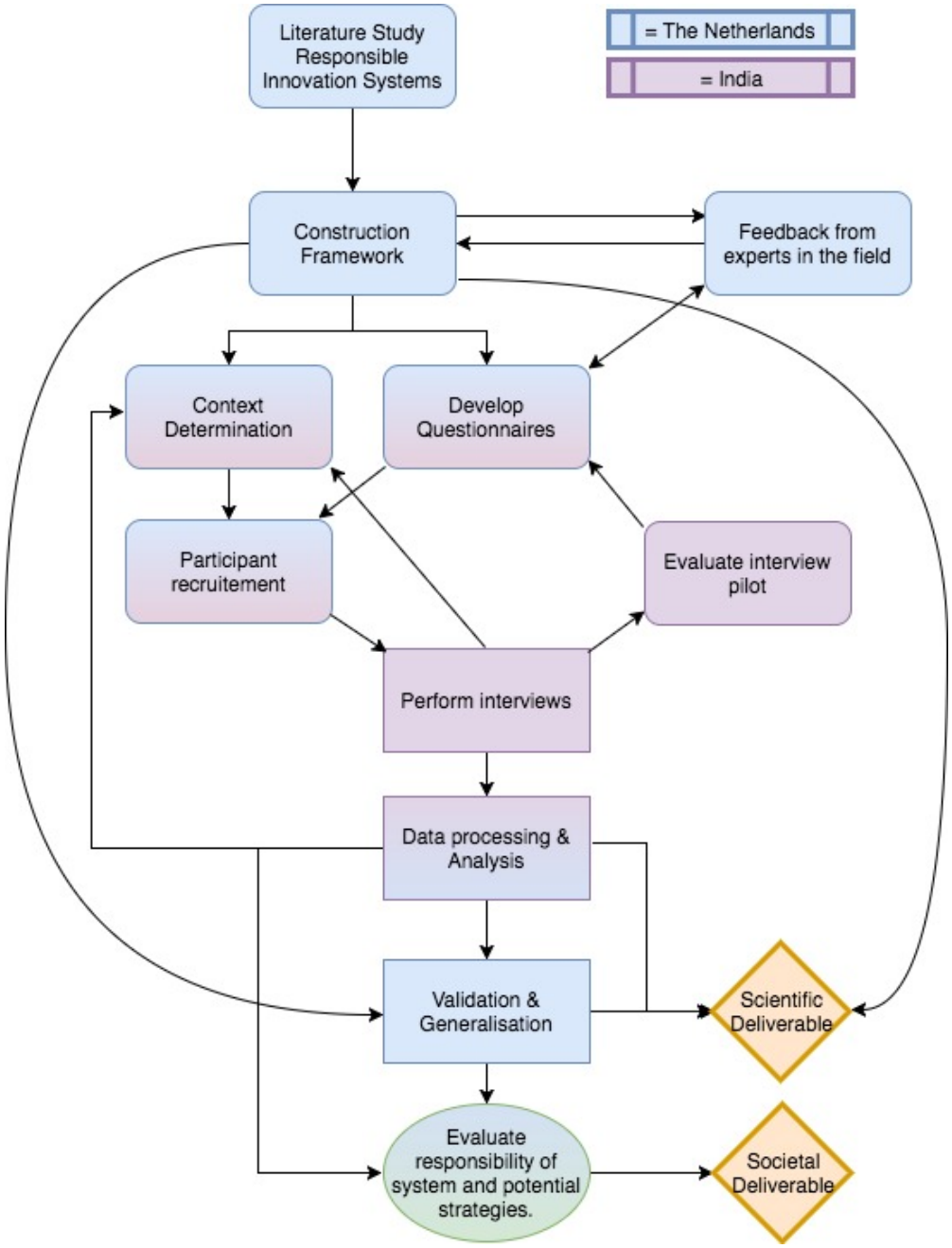


Figure 2.1: Flowchart of research methodology

3

Responsible Innovation Systems

What is a responsible innovation system? - This section tries to answer this sub research question, which can be segmented in two separate questions. The chapter is divided in two main sections, Section 3.1 that tries to go deeper into the concept of responsible innovation and Section 3.2 that explains how innovation systems and relations in it can be approached from the theory. Finally in Section 3.3 the discovered theories will be discussed in the light of their possible use in a combined framework for responsible innovation system. To be able to fully understand the theoretical approach towards innovation, some preliminary knowledge on 'innovation' and 'knowledge' from an academic perspective might be required. It is therefore that Section A in the Appendix has been added for readers who are unfamiliar with such a theoretical approach to innovation. It introduces the extensive variety of literature on which theories explained in this chapter are building.

3.1. Responsible Innovation

What is responsible innovation? Responsible Innovation (RI) can be seen as an attempt to an early stage consideration of societal and ethical problems. It has only recently been pursued to develop a RI framework. (Stilgoe et al., 2013) Certain externalities can be assigned to innovations that at forehand were not expected. The use of fossil fuels, for example, is looked upon very differently nowadays. If the externality of climate change would have been anticipated, what would the choices have been then? And now that the implications of climate change are becoming clear, who is going to take the responsibility? A modern view on responsibility in innovation is that it should be essentially shared among society. (Von Schomberg, 2007)

Owen, Stilgoe and Macnaghten argue that a complete reconfiguration of the system is needed in the way innovations are currently done. They define RI as: *"Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present."* They claim that the capacity to responsible innovation is a skill that is learnt and should therefore be nurtured. This makes a case for education and the development of competencies that are multi- and inter-disciplinary, compassing several institutional contexts. (McGregor and Wetmore, 2009) Ideally, RI should not only want to redesign a technology, but also reinvent the structure of institutions, since designed artefacts by these institutions inevitably contain the values they hold. (Taebi et al., 2014) By simply redesigning the technology to better synchronise values, the root of the problem is not addressed, since it lies in its creator.

Addressing societal problems that can only be solved with the inclusion of multiple institutions, requires extensive collaboration between those different institutions. However, institutions often have different sets of goals and ways to define the problem at stake. They have been designed to address specific societal problems, creating ways to hold actors within the institution accountable for their decision processes and actions. Crossing the boundaries between institutions creates new sets of problems. New technologies often find themselves in what Hajer (2003) calls an institutional void. In other words, there exist no accountability structures to guide collaborations to prevent conflicts between institutions. Developing a shared understanding of the problem at hand, or consensus, is crucial in getting inter-institutional collaborations to a successful end, thereby assuring the satisfaction

of all stakeholders (Verbong et al., 2008) and the inclusion of each institution's values in the decision making process and the path of innovation. It is therefore important to take institutional differences into account. Lastly, the nature of the collaborations that stakeholders construct can take different forms. The differences between collaboration types and what those differences mean for development and transition of the technology or the knowledge in the innovation system needs to be considered.

3.1.1. Responsible Innovation Dimensions

The Responsible Innovation framework can be used as a guideline towards new innovation processes or as an assessment of current processes. The framework consists of four dimensions to which one must commit: Anticipation, Reflexivity, Inclusion and Responsiveness. In Table 3.1 these are presented with their definitions as used during this research. It must be noted that the dimensions do not represent clear distinctions, but are rather deeply intertwined. They can reinforce each other, but might also create tensions, resulting in new conflict, as Stilgoe et al. (2013) show in a case study. It emphasises the need of applying all dimensions in frameworks, instead of individually taking the dimensions as design criteria.

Anticipation

To anticipate is to systematically think about increasing resilience and revealing new opportunities for innovation. It forces to ask 'What if..?' questions. The prospect of future situations in development is not something new, as techniques such as forecasting are already applied extensively. (Coates et al., 2001) Risk analysis is a technique that is widely used and can also be counted to contribute to this dimension, for example. However, future visions are not only created to make predictions, but also to shape desirable futures. (Te Kulve and Rip, 2011) Setting goals and targets are, therefore, also an important factor.

Reflexivity

Reflexivity is the ability to mirror ones own actions and be aware of one's limitations, realising that views of different parties are often not similar. Wynne argues that there exists a need for increased institutional reflection. (Wynne, 1993) Not only should institutions reflect on themselves, but must also aid in building the reflective capacity of the entire systems. This requires, for example, multi-disciplinary collaboration and training.

Inclusion

Inclusion sees to a deliberative approach towards connecting with stakeholders and letting them participate in the design process. Open Innovation, which will be further discussed in Section 3.2.3 can be seen as a tool that increases inclusion. However, inclusion in the form of consumer participation, for example, does not always deliver the wanted results. (Rothstein, 2007) It appears that inclusion of whatever actors should be more closely examined, before ascribing it to being solely beneficial, creating a tension, as was earlier described.

Table 3.1: Definitions of the dimension as used for this research, interpreted from Stilgoe et al. (2013)

Dimension	*Definition*
Anticipation	Determining future visions, risks, effects, opportunities and situations. Asking the question 'What if..?' and setting goals and targets.
Reflexivity	A retrospective view on one's own role and those of others, by holding a mirror up to the activities, commitments and assumptions and how this affects others in society.
Inclusion	Participation of all relevant stakeholders that might influence innovation and are influenced by innovation, in the several phases of the process.
Responsiveness	A capacity to change shape or direction in reaction to changing circumstances.

Fiorino (1990) already claimed that participation of stakeholders in policy-making could serve as a way for democratic and socially supported technologies and projects that sustain. Consensus on policy measures and goals should therefore be formed between stakeholders. For this research it is presumed that for Responsible Innovation to emerge in complete systems, the inclusion dimension acts as the gateway dimension, for otherwise there is only responsibility on one's own island of innovation. Furthermore, the inclusion dimension is most tangible of the four, creating clear criteria for potential measurements.

Responsiveness

Changing circumstances require a responsive reaction. Organisations must be able to adjust their shape and direction when the environment around them is not harmonious with their current path. Stirling (2008) noted, for example, that the shift towards a more social decision process in technological processes is not sufficiently happening, preventing cohesion between political and social actors. This can be ascribed to a lack of responsiveness of governments to the more inclusion demanding public that is the result of a more knowledge intensive society. In other words, institutions and actors need to be able to respond to new emerging knowledge and views. Value-sensitive design is a technique used to create responsiveness and was used in this research, through a socio-technical value mapping, to create a communication strategy for interactions with Indians. The focus on institutions is also mentioned, showing the importance of taking into account institutional differences within systems.

3.1.2. Responsible Innovation in SMEs

The four dimensions provide a general framework, however, they show that contextual institutional influences are of importance, requiring case specific adjustments to be considered. Most interviewed companies, as will be seen later, are small and medium enterprises (SMEs). How will Responsible Innovation influence the processes in these types of small technological organisations? Research on Responsible Innovation is primarily conducted in the perspective of policy and science, while the industry side remains a grey area. (Pavie et al., 2014) Valdivia and Guston (2015) proposed three initiatives for industry, government and academia. The industry initiative is a managerial philosophy to promote Responsible Innovation called Corporate Social Responsibility. However, Hemphill (2016) calls for caution of this approach and proposes to use a different one, namely Corporate Citizenship, which was deducted from corporate behaviour and has a more practical use. Corporate Social Responsibility (CSR), however, was developed for large corporations and has been criticised to be of little use in Small to Medium Companies (SMEs), that are often constrained by resources. A more suitable terminology was found in Responsible Business Practice by Moore and Spence (2006). Halme and Korpela (2014) connected the term to the definition by Dahlsrud (2008) as follows: *The ways and means by which SMEs integrate environmental, social and long-term economic concerns in their business operations and in their interactions with stakeholders.*

Scholten and Van der Duin (2015) have provided a conceptual model for start ups that contains Responsible Innovation practises. They state that the dimensions of Responsible Innovation are very suitable for use in private organisations by directing the innovation processes to being more sustainable. Businesses should maximise the creation of shared value for stakeholders and society, which resonates with the objective of this research to mutually benefit the organisation and the system. To reach this maximisation of shared value, the business must optimise the different values of the stakeholders and try to align them. (Jones et al., 2007) Applying an innovation strategy with inclusion of stakeholders helps start ups to better gain and translate external knowledge. (Pavie et al., 2014) Scholten and Van Der Duin eventually draw the parallels between Responsible Innovation practices and absorptive capacity, which is the capacity of acquisition, assimilation, transformation and exploitation of new external knowledge. Their findings indicate that the Responsible Innovation practices of stakeholder engagement increase the absorptive capacity of a firm. However, active stakeholder engagement also comes with a flip side, because Blok and Lemmens (2015) showed that businesses have good reasons to be weary for sharing key information with stakeholders. Also, active engagement of stakeholders costs a significant amount of time and resources. (Orlitzky and Swanson, 2008) Halme and Korpela (2014), however, find that SMEs can create responsible innovations with a variety of combinations of resources, such as equity, research and development cooperation, networks, industry knowledge

and reputation. These findings have a strong resonance with research on Open Innovation further explained in Section 3.2.3.

It seems that Responsible Innovation can be beneficial to firms, however, the true benefits in small firms are still unclear, since the literature that surrounds Responsible Innovation still needs to mature and some drawbacks can be noted. For the sake of this research, still the findings are important. The general view in the literature is that Responsible Innovation practises should eventually benefit the larger system, of which the business itself is inevitably a part. But can the dimension so easily be transferred to a systemic level? To answer this question a deeper dive into the literature on what Responsible Innovation means for larger systems needs to be done.

3.1.3. Systemic Responsible Innovation

A system of innovating actors each trying to become responsible, while every additional node in the system creates more innovation dynamics and makes responsibility more complex. While next Section 3.2 goes deeper into the concept of innovation in systems, what can at least be said already about responsibility in such a system?

While the initial framework by Stilgoe et al. (2013) incorporates the systemic nature of responsibility in the inclusion dimension, the framework does not dictate what this dimension needs to consist of or claims to be applicable on a holistic view above this system, but rather on the organisation scale.

So what help could such a holistic view be? Institutions have their own set of actions to ensure responsibility, for example, as universities have the peer-review process. But what if the institution of university comes together with industry, who's responsibility it is in turn is to supply to the demand of another institution, namely the public, who in turn is governed by policies? Does the time consuming peer review process deliver full responsibility for every actor? To define the term responsibility in a complex innovation system is still one of the challenges in the current development of Responsible Innovation theory. (Owen et al., 2012) While no coherent framework is yet presented, some research has tried to give some answers that help in building such a framework. 'Which aspects of stakeholder analysis are important to consider when a definition of the term 'responsible' in Responsible Innovation is developed?' (Thomas and Rogers, 2016) This question, among two others, was answered in research on a car manufacturing innovation system. The answer reads:

- *"The interests and influences of stakeholders frequently change. To address stakeholder demands, "responsibility" in Responsible Innovation needs a dynamic definition which is recurrently and continuously fixed, controlled, revised, and adapted to environmental changes. The groups of stakeholders, to which responsibility for an innovation can be assigned, do not change over time.*

It seems that stakeholder groups, or institutions as will be the prevailing term in this report, are constant throughout the collective innovation process and a changing system. However, there is also a changing environment within and around these institutions. From the two other answers, the scholars find that the early stage of an innovation system already shows those groups and that industry, government and customers have significant influence. The research, arguably, fails to see its own contribution to the system. While it is maybe not a directly visible influence on performance, the academic contribution of the research does serve a purpose in knowledge transfer. In a knowledge society, after all, knowledge is an asset of value.

Still, this does not answer the question of what a responsible innovation system is. van Geenhuizen and Ye (2014) approach it from the other side. They find indications that responsible innovation is one of the drivers of openness in knowledge networks. Logically reversing that would say that open networks facilitate responsible innovation. However, papers that hinted in their abstract towards addressing systemic responsibility were often, ironically, not for open access. The December 2016 edition of the Responsible Innovation Journal contains several articles that deal with the same question, however the journal was not open for review at the time of writing.

An article from 2003 does lay ground for what such an open knowledge network could be. (Hellström, 2003) Already there, the need for design principles for preventive foresight (anticipation) and systemic governance of responsible innovation becomes apparent. It proposes, in Hellström's own words: *"Arenas of trustworthiness and informal joint authority created between a number of actors who may be involved in significantly creating, perceiving and transforming risk generating practices with respect to a technological system"*. On the question which actors should make up this arena, Hellström argues that

the full cycle of risk of irresponsibility shoud be included, containing joint product/process creators and risk identification, negotiation, public facilitation, regulation and monitoring. Though, he also places a view side notes.

3.1.4. Limits to Responsible Innovation

Hellström acknowledged in 2003 that that in order for systemic responsible innovation to happen, mutual trust in the system is required and some form of intellectual property protection is needed. Another recent article has done a case study of Responsible Innovation in biofuel innovation in South-India and finds some important barriers for activities to contain RI dimensions. (De Hoop et al., 2016) They find that the difficulties contain material barriers, changing from existing practices to new and its costs, unwillingness of stakeholder involvement, power differences and dependencies, (un)clear demarcation of responsibilities, strategic behaviour and diverging or even contradictory interests. The case study shows several instances in which stakeholders did not cooperate, did not try to align interests or did not harmoniously strive for consensus. It shows that on the systemic level, RI dimensions might be applied to an individual organisation, but not mutually transferred and aligned among peers, still creating irresponsibility in the system. In order to get a better idea of what the relations and interactions in innovation systems actually contain, next Section 3.2 will go deeper into the concept of innovation systems and open knowledge networks. Before a deeper dive is done into systemic innovation, it is necessary to recapitulate the current definition of what responsibility in the collective innovation process means.

3.1.5. Responsibility in the collective innovation process

The collective innovation process can generate unfavourable outcomes that are spawned by irresponsible behaviour. To filter irresponsible processes, responsibility must be assigned to innovation processes. The framework of Responsible Innovation by Stilgoe et al. (2013) aims to do this by applying the dimensions of anticipation, reflexivity, inclusion and responsiveness to the innovation process. These dimensions are intertwined and might strengthen or counteract each other, dependent on the specific tool that is being used to enhance the dimension.

In SMEs, responsibility according to these dimensions has shown to increase the absorptive capacity of firms, however, it is unclear in what way the effectiveness of activities is altered because of increased resources put in RI activities. In systemic behaviour, responsibility needs to be defined dynamically that can adapt to changes in the system. A constant in this evolving environment is the institutions that influence innovation. Also those institutions, in order to behave responsibly, most likely need to have open knowledge transfer across their boundaries. It is also shown that while Responsible Innovation might be applied at the organisational level, if not transferred and aligned to others in the system, irresponsibility will still prevail.

So what entails responsibility in the collective innovation process? For now it can be said: Responsible innovation in the collective innovation process is the application of the intertwining dimensions of anticipation, reflexivity, inclusion and responsiveness in an evolutionary environment with actors of an innovation system that contains a constant group of institutions, while absorptive capacity allows for open knowledge transfer in and out of organisations.

3.2. Innovation in Systems and Relations

What is an innovation system? - The term 'innovation system' spawns from the theory of Systems of Innovation (SI) and has become a generic term for complex relations between actors.(Edquist, 1997) However, the theory of innovation is not reliant on a single school-of-thought, as can be seen from Appendix Section A. It is therefore that a variety of institutional arrangements and policy models as explanations for innovation dynamics in systems exist. This chapter will elaborate on some of these approaches, that were partly derived from a literature review by Hessels and Van Lente, a paper by Etzkowitz and Leydesdorff and a report by Twoney and Gaziulusoy. (Etzkowitz and Leydesdorff, 2000) (Hessels and Van Lente, 2008) (Twomey and Gaziulusoy, 2014) The theories presented in this section will later serve as the base for the attempt in Chapter 4 of constructing a framework for responsible innovation systems.

Many approaches towards structuring innovation have included the handling of complex relations,

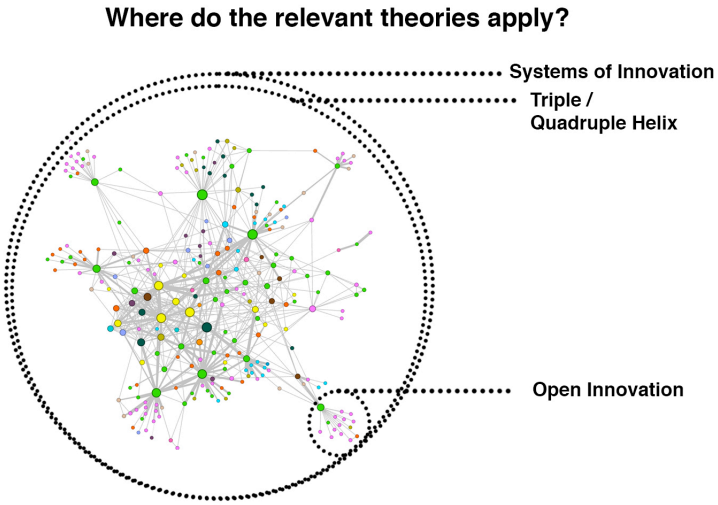


Figure 3.1: The scale on which the different innovation theories apply, where the network represents an innovation system

opposed to the historical view of linear innovation (see also Appendix A). However, while acknowledging the changing environment for science and knowledge production to more heterogeneity of different actors, for most of these approaches the focus remains on innovation as a result of mainly academic activities. Since former section clearly showed that responsible innovation requires an inclusive approach of multiple types of actors with potentially equal contributions to innovation, those university-focused theories were considered unfitting for this research. The approaches that disqualified in this perspective are *Post-Academic Science (Ziman, 1994), The Post-Modern Research System (Rip and Van der Meulen, 1996), Finalisation Science (Böhme et al., 1976), Strategic Research (Irvine et al., 1984), Post-Normal Science (Funtowicz and Ravetz, 1995), Academic Capitalism (Slaughter and Leslie, 1997)*. However there is still a great deal of overlap with these perspectives, since many of these theories do acknowledge the increasing role of industry or government as innovation partners, but fail to see it as an equal institution.

The theories that have been subject to further consideration, since they opt for a broader inclusion of knowledge producing stakeholders, are **Systems of Innovation** (Edquist, 1997), **Triple Helix & Quadruple Helix** (Etzkowitz and Leydesdorff, 1995) (Carayannis and Rakhmatullin, 2014) and **Open Innovation** (Chesbrough, 2006). In, respectively, the sub sections 3.2.1, 3.2.2 and 3.2.3 these theories will be more thoroughly explained. Figure 3.1 shows on which scales these innovation theories apply, to aid a better comprehension in the following sections. On both the holistic and the relational scale a description on the workings of an innovation is sought, to be able to draw to complete picture of what an innovation system actually contains.

3.2.1. Systems of Innovation

From work of Freeman, Lundvall and Nelson, that initially introduced National Systems of Innovation, the theory of Systems of Innovation (SI) has emerged, popularised by Charles Edquist. (Freeman, 1995) (Lundvall, 1992) (Nelson, 1993) (Edquist, 1997) For more than 2 decades, it has been widely applied for making innovation policy. Edquist defined an innovation system as: *"all important economic, social, political, organisational, and other factors that influence the development, diffusion, and use of innovations."* The model is not meant to show the results of innovation but to expose all determining factors of innovation, also referred to as functions of innovations systems (FIS). FIS was introduced by Hekkert to show how the systems are driven towards development. (Hekkert et al., 2007) Failures in the system can be ascribed to roughly three causes. Either missing or malfunctioning agents, relationships or institutions. (Metcalfe, 2005) Systems of Innovation can be approached with different concepts. National, regional and sectoral innovation systems can be identified, where the first two are geographically bound. A sectoral innovation system may take the form of a technological innovation system, including all relevant dynamics of a single technology. Nine characteristics, however, are

shared by the systems of innovation approaches.

1. Innovation and learning is at the centre of focus
2. A holistic and trans-disciplinary approach
3. Historical perspectives are used for better understanding of the system
4. Systems are allowed to be of different structures
5. Interdependence between elements in the system and non-linearity
6. Inclusion of both product innovation as organisational process innovations
7. Central role of institutions
8. Conceptual pluralism of the approaches
9. Conceptual frameworks rather than formal theories

Lengyell and Leydesdorff showed by an analysis, that in the case of Hungary it is more suitable to speak of a combination of regional innovation systems, instead of a single national innovation system. (Lengyel and Leydesdorff, 2011) This arose from the separate development of regions, that had little interaction in the development process. India, being a large and diverse country, is expected to be difficult to contextualise in its completeness and a regional focus may be valuable. Other literature also sees the regional approach as a better building block. (Chung, 2002) It seems evident that communities near the border of Nepal in the North are in little contact with communities in the South of India. Also State policies within India can differ immensely. Furthermore, firms and organisations that are closely located to each other happen to have better interactions. (Lundvall and Borrás, 1997) This is also shown for developing countries. (UNIDO, 2004) Especially for small firms it holds that external relations are more regionally based compared to larger firms. (Morgan and Cooke, 1998) This observation can be ascribed to the dependence of smaller firms on tacit knowledge, of which Section A.1.1 showed that it is foremost present in local informal networks. An interesting paper by Lawson and Lorentz shows the importance of a regional focus and argues that informal relations and tacit knowledge exploitation can give a regional advantage. (Lawson and Lorenz, 1999) While the case study asks for the rural energy technology innovation system of India, because of these observations, it makes more sense to look at India as a combination of regional innovation systems, possibly bounded by State borders, since these have varying policy environments. Furthermore, a combination may be sought to integrate this with the Technological Innovation Systems approach, since rural energy technology does not exactly entail a single technology, as will be seen in Chapter 5. A combination of regional and technological innovation systems is called 'clusters', a term introduced by Porter. (Porter, 1998)

Regional Innovation Systems and Clusters

A regional innovation system can be defined as "constellation of industrial clusters surrounded by innovation supporting organisations". (Asheim and Coenen, 2005) Regional Innovation Systems is widely accepted as a suitable framework for research. The connections or inter-linkages in such systems are the relations, as Systems of Innovation describes. A well functioning regional innovation system is defined by the intensity of the relations between its components, interactive learning and the facilitation of knowledge circulation due to geographical proximity. (Chaminade and Vang, 2008) In other words, when one has strong and close relationships with actors and learning between them is happening the system fulfils its function.

A study on the software industry in Bangalore has shed a light on the processes that are present during the emergence of a regional innovation system in an emerging country like India. (Chaminade and Vang, 2008) It positions the regional innovation system as a globalised hub for innovation, claiming that formerly low value adding activities are being traded for activities that are higher on the value chain, implying a higher innovation level and a higher relevance in the global innovation environment. The scholars argue, however, that there should be a more evolutionary approach towards the emergence and change of a regional innovation system, which is currently absent in the theory. It also makes some claims on the use of policy in the different stages of the maturing system. A more flexible policy structure is needed to cope with the constantly changing regional innovation system. Figure 3.2 shows

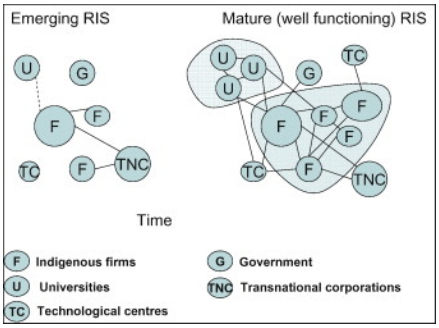


Figure 3.2: Transition of the RIS (Chaminade and Vang, 2008)

a possible configuration of a regional innovation system and its transformation.

The role of the university in knowledge creation of a regional innovation system is also acknowledged by many. (Godin and Gingras, 2000) (Fromhold-Eisebith and Werker, 2013) However, recent research suggests with empirical evidence that the contribution of universities is often exaggerated, making a case for the assumption of incorporating the innovation theories that look beyond the academic scope as the main innovation driver. (Brown, 2016) A more in-depth look towards the linkages that universities and research institutes in the Indian cities of Bangalore and Pune have formed with industry partners is given by Basant and Chandra. (Basant and Chandra, 2007) Figure 3.3 shows the dynamics they find to be important, again also including policy as an influence. It also specifically mentions social capital, from which civil society can be seen to arise as a result. Fukuyama (2001)

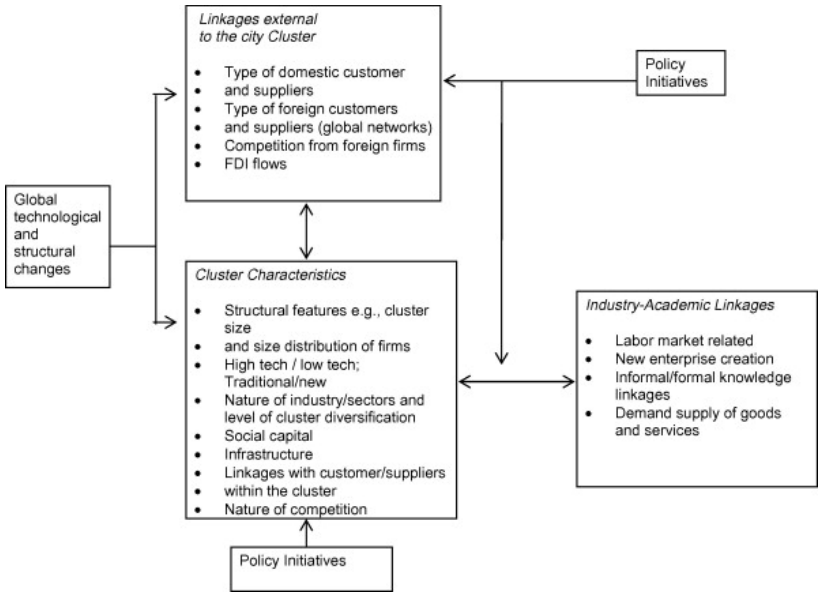


Figure 3.3: Industry–academia linkages in city clusters (Basant and Chandra, 2007)

Critique on Regional Innovation Systems

The lack of an evolutionary approach in the theoretical foundations of Regional Innovation Systems, as derived from the paper on the software industry in Bangalore, is not the only critical note to be found. Doloreux and Parto have done a critical synthesis on the concept of Regional Innovation Systems and come with some interesting findings. (Doloreux and Parto, 2004) They conclude that regional innovation systems can help show that innovation in regions benefits from, for example, firms that behave more strongly as innovators or collaboration between organisations outside institutional barriers in the system. It therefore helps expose some important requirements for innovation to occur that

support the objective of this research. However, they experience some confusion among publications. The wide variety of the introduced region types has blurred the clear boundaries that determine such a region. Because of this absence of a defined region, the conceptual framework lacks consistency and it was even questioned if the model can be used for policy intentions as recent research from Italy suggests, while also praising the model on other elements. (De Marchi and Grandinetti, 2016) Tödling and Trippl have tried to overcome these difficulties by trying to introduce a differentiated regional innovation systems approach, that accounts for differences in geographical characteristics. (Tödtling and Trippl, 2005) Furthermore, little research tackles the possibility of international relations that the innovation systems can have and that can contribute to development. (Carlsson, 2006) Some evidence on regional innovation systems in Norway suggests that external knowledge from global sources is important to consider, but a coherent conceptualisation of the matter remains absent. (Asheim and Isaksen, 2002) This could prove problematic, since current knowledge on rural energy technology is spread around the world and for state-of-the-art technology to be applied in India, global connections are necessary to consider.

In general, the discussion around Regional Innovation Systems is not yet tempered. Evidence shows its usability in several situations, however there exists a lot of uncertainty on drawing the geographic boundaries that will form the region, the establishment of international connections and an evolutionary approach towards changing systems. Remembering what responsible innovation in the collective innovation process means, these changes in a system are necessary in, for example, an anticipatory and responsive attitude. Helix theory, which is introduced next, seems to consider at least the latter two critiques of Regional Innovation Systems in a better way.

3.2.2. Helix Theories

Another description of innovation that is gaining momentum in innovation policy circles is the Helix theory, first described in the Triple Helix (TH), introduced by Etzkowitz and Leydesdorff. (Leydesdorff and Etzkowitz, 1998) It describes the different helices of Government, Industry and University (GIU) as knowledge producing entities, or institutions behaving as selection environments. In other words, they are decision making structures that incorporate the values of the institution in the innovations. The model claims that innovation is boosted by maximised synergy between the helices where they overlap, so where collaborations between the institutions are happening and selection environments are overlapping so that each institution's values are incorporated. Every helix is also expected to partly take over responsibilities, in case of weak institutions or as means to diversify, but remain close to their core activities as well. The term co-evolution comes in to play in this model as the three institutional spheres are seen as interdependent. Figure 3.4 shows this graphically, with in this case Science (S), Business (B) and Government (G), however, in this research the GIU notation will be prevalent. It must be pointed out that the figure presents an ideal situation. If no structures for communication or collaboration exist between the spheres, there is no overlapping space and the spheres behave in a more 'laissez-faire' manner, or in other words, operating on their own. However, whenever overlap occurs, it means that intermediary or hybrid organisations and collaborations exist, that compass multiple institutional selection environments.

Evolution is an important term in the Triple Helix context. Triple Helix does not try, compared to Systems of Innovation and Mode 2 (further discussed in Appendix A), to be descriptive, but takes the assumption that the internal environment of different spheres is in constant transition. (Etzkowitz and Leydesdorff, 2000) Stilgoe, from the Responsible Innovation framework, also claims that the interaction between society and technology is constantly changing and Thomas and Rogers equally found changing interests and influences. (Stilgoe et al., 2013) (Thomas and Rogers, 2016) This has close connections to what Schumpeter called creative destruction in evolution economics. (Schumpeter, 1934) Triple Helix is not trying to prove other theories wrong, it rather sees them, such as Mode 2 and Systems of Innovation, as sub-dynamics of GIU relations. (Leydesdorff, 1997) Etzkowitz and Leydesdorff draw a connection to Systems of Innovation, by stating that a disorganised and fragmented nature of innovation systems is accounted for in Triple Helix by a reflexive overlay of relations among its components. Triple Helix could therefore be seen as a conceptual addition to Systems of Innovation theory, explaining the transitions that system undergo, which was a shortcoming of Systems of Innovation discussed in Section 3.2.1. (Etzkowitz and Leydesdorff, 2000) In the light of Responsible Innovation, Triple Helix delivers an important supplement of the reflexivity, anticipatory and responsiveness dimensions of RI. Firstly, the assumption of a changing environment allows for a better description of future risks. Secondly,

an organisation can easier categorise itself in respect to others and show fundamental differences in the perspective of institutional characteristics. Lastly, with this information the organisations are better equipped to respond to changing environments. At the same time, arguably, the inclusion dimension is touched, since relations can more easily be categorised and important missing institutions are more easily spotted in one's surrounding network.

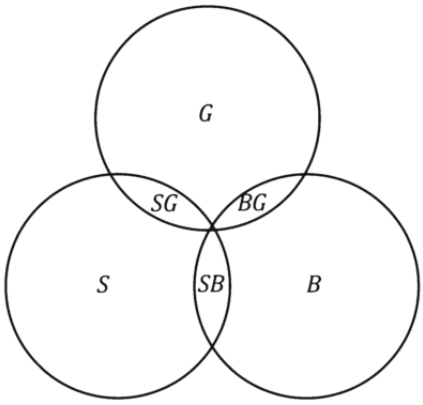


Figure 3.4: Institutional spheres forming bilateral interactions (Ivanova and Leydesdorff, 2013)

Two major perspectives in the current literature can be identified. (Meyer et al., 2014) At first, the neo-institutional perspective, that examines the enlarged role of university in innovation, presenting it with its 'Third Mission' as being an entrepreneurial university. The commercialisation of knowledge from R&D is central in research that holds this perspective. (Etzkowitz, 2002) The second perspective is that of the neo-evolutionary. It spawns from the social systems of communication theory by Luhmann (1975) and mathematical communication theory by Shannon (1949) and approaches GIU as social sub-systems that reshape their internal and communicative structures with reflexive sub-dynamics, such as Mode 2 and Systems of Innovation. The evolutionary approach calls for a more systemic view on Triple Helix. (Etzkowitz and Ranga, 2010) Leydesdorff and Meyer (2006) have defined the three functions of the different spheres in such a systemic configuration: Normative control (Government), wealth creation (Industry) and novelty production (University). Figure 3.5 shows the graphical representation of this. The visualisation allows for an easier comprehension of how intermediary organisations should be positioned in relation to the functions of the institutional spheres.

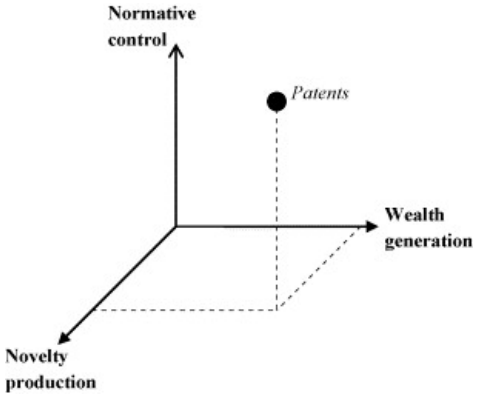


Figure 3.5: An analytical scheme for studying the Triple Helix as a neo-evolutionary model. (Leydesdorff and Meyer, 2006)

Relevant Research Evidence on Triple Helix

Evidence from a study on Triple Helix in China suggests that cooperation as presented by the Triple Helix is indeed beneficial, at least in economic terms. (Chen et al., 2016) Examining 552 high tech firms and 56 universities, they find that different types of cooperation provide varying economic benefits to

the parties. Five cooperation modes between academia and industry were researched, ordered from most beneficial to least and percentage of profit increase in the brackets:

1. High-tech firms develop R&D achievements in cooperation with universities (77%)
2. High-tech firms employ technological personnel from universities. (35%)
3. High-tech firms purchase R&D achievements directly from universities (21%)
4. High-tech firms consign R&D missions to universities (9%)
5. High-tech firms set up R&D organisations with universities (7%)

It shows that there exist differences in economic benefits of activities in the overlapping of institutions. In terms of responsibility, it might be expected that different activities also contribute differently. However, on the specific relations the Triple Helix itself does not say much and has been an addition of the researchers of above results. Next Section 3.2.3 on Open Innovation tries to dive deeper into this.

Regarding India, a 2006 paper sheds a light on how Triple Helix can show certain transformational gaps. (d'Costa, 2006) The information technology sector in Bangalore has been internationally recognised for its successful development. However, the paper argues that the structure of the current system is based on an Indian business model, as being an outsourcing location for the US industry, that is not responsive to to changes. It exposes significant shortcomings in the institutional architecture, with the absence of inter-institutional relations and a lack of diversity of knowledge production that can be used for the domestic market as well. A gap in a dimension of RI, namely responsiveness, is exposed with the Triple Helix approach. These findings present implications for strategies and possible focus points for policy makers. However, it does not yet cover the full spectrum of possible collaborations. A very recent research by Vivek Kumar Singh has analysed 459,164 records on GIU relations in India. It defines cooperation between institutions on the intersections of UI, UG, IG and UIG. It shows that the engineering sector, compared to for example the medical sector, is delivering a below standard performance in creating synergy between the institutions.

Critique on Triple Helix

The Triple Helix model is not without criticism. Some research has given voice to concerns about the possibilities of using Triple Helix as an explanatory model. Tuunainen and Shinn are in doubt about the capacity of Triple Helix to sufficiently explain the complex relations between GIU. Two major limitations spawn from their research, the first being that the model is to broad, unable to examine all dimensions in the relations. Second they claim that there is insufficient consideration about the Intellectual Property (IP) rights when the commercialisation of knowledge is concerned. (Tuunainen, 2002) (Shinn, 2002) Their findings ask for a better look on how relations and connections are formed in the Triple Helix environment. As suggested earlier, Open Innovation can be a suitable candidate in resolving these issues. Interestingly, Fitriati et al. (2012) argue, while reviewing the Indonesian National Security System, that the original division of constant institutional spheres is not sufficient and argue for the extension of a fourth sphere that influences innovation. Their call for extension, as will be seen, is not the only one in the field.

Extensions of the Triple Helix

Much research on Triple Helix is done to improve and extend the model. The latter is seen in a proposition by Ranga and Etzkowitz that combines Systems of Innovation and Triple Helix calling for a different set of functions, that relate more to the systemic knowledge diffusion and usage. This appears to be a more beneficial view for the objective of this thesis. (Ranga and Etzkowitz, 2013) In the discussion at the end of this chapter, more will be said on the Triple Helix Systems, as their combination of Systems of Innovation and Triple Helix is called.

Improvements are rapidly coming up, with the wider adoption of Helix theory. Meyer et al. (2003) tried to find indicators of hybrid organisations or projects in GIU relations. (Leydesdorff, Park, and Lengyel, 2014) and (Strand, Ivanova, and Leydesdorff, 2015) sought to make the synergy between GIU relations quantifiable by using by such indicators.

A significant extension to Helix theory come from Carayannis and Campbell (2009), who have proposed

extensions of the Triple Helix by introducing a fourth and fifth helix. In 2009 the paper on the Quadruple Helix (4H) was introduced, aiming to include a media-based and culture-based public and civil society as a fourth sphere, creating government-industry-public-university (GIPU) relations. When looking at the development of cities, Cohendet and Simon (2008) note that next to the three institutions of Triple Helix, communities provide the structures that see to a successful integration of activities. This poses as an argument for the Quadruple Helix extension in a regional focus, that often has a city at its epicentre. (Malecki, 1997) The importance of the community is also acknowledged in several European initiatives that have sought a more inclusive decision process, trying to get public opinions upstream in the discussions around introduction of new technologies. (Houghton, 1998) (Wilsdon and Willis, 2004) (Macnaghten and Chilvers, 2014) The tools that are used to create this so called 'mini-public' are: "Consensus conferences, citizens' juries, deliberative mapping, deliberative polling and focus groups". (Chilvers, 2010) However, the participatory approach to decision making and upstream inclusion of the public is not without its critiques. (Rothstein, 2007) Still, the connection to the RI dimension of inclusion, and potentially also others, becomes enlarged by the extension with the public/ civil society as a sphere. Imagine the potential of responding much earlier to public dissatisfaction with a technology, because it became apparent during the participatory approach. The whole public protest against windmills being installed in people's backyard could have saved a huge amount of time in The Netherlands if consensus on this development was reached earlier, for example. Ivanova (2014) has taken 'media' as the word to express the totality of existing institutions engaged in communicative and informational impact on society. It explains how information reaches the public through different channels such as Internet, television but also social networks which are yet most relevant in communities in rural villages that are now beginning to learn what the Internet is.

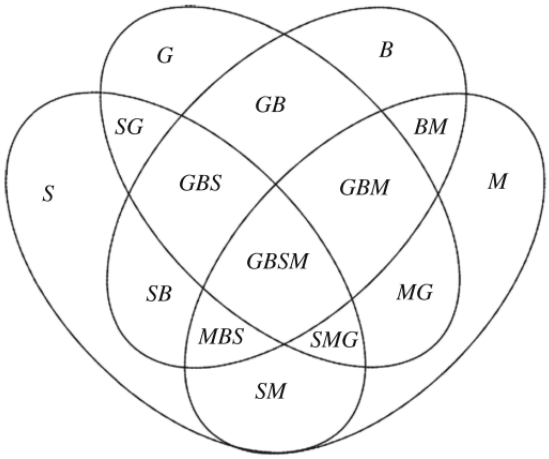


Figure 3.6: A balanced Quadruple Helix model (Ivanova, 2014)

Figure 3.6 graphically shows the Quadruple Helix and the different types of overlap within institutions, where in this case Media (M) was added as a fourth sphere. But does adding a fourth sphere really make any sense? Empirical evidence on 4215 firms located in European science parks has shown that firms operating with the fourth helix taken into account generate significant better economic performance and spawn more innovation than those who do not. (Campanella et al., 2017) While this still says nothing about full responsibility in a complete system, the economic indicator cannot be put aside. Ivanova explains the many more possibilities of intersections from the knowledge and innovation perspective as: *"The Quadruple Helix approach can add crucially to the prospects and opportunities of a sustainable innovation generation."* This does not only account for competing national economies, but also for individual companies, due to the fractal complexity of the system. (Ivanova, 2014)(Carayannis and Rakhmatullin, 2014)

Now a more abstract turn is taken to understand the knowledge creation as conceptualised by Carayannis and Campbell in the Quadruple Helix, so that one can understand to a higher extend what the Quadruple Helix is actually based on. With the introduction of 4H, Mode 3 as a knowledge creation

system was also proposed, as also described in the historical and academic view on innovation in appendix A.1.1. Mode 3 as a sub-dynamic in the Quadruple Helix would acknowledge the co-existence and co-evolution of distinctive knowledge and innovation paradigms. Mode 3 allows for both *'top-down government, university and industry policies and bottom-up civil society and grass roots initiatives'*. (Carayannis and Campbell, 2012a) These introductions, they say, lead to a fractal knowledge innovation system that is equipped for a knowledge democracy and allows for the Quadruple Helix to exist. (Carayannis and Campbell, 2011) Fractals are natures way of sustained growth. A continuous repeating pattern, that is able to scale, but still remains recognisable. In other words, a fractal is a sustainable recurring pattern. Nature shows fractal features in numerous things. Leaves, blood vessels, crystals, the rings of Saturn and yes, the DNA double helix itself, all show patterns that can be described as a fractal. These arguments lean to a more mathematical explanation of knowledge and innovation. And as is not uncommon for mathematics, it can be used for solving even higher dimensions.

The introduction of the Quintuple Helix (5H) follows from the logic that if the Triple Helix is embedded in society and society itself is embedded in nature, nature should be the fifth sphere. The Quintuple Helix aims to describe the environment for an even more inclusive approach, and therefore more responsible, to an innovation system. (Carayannis et al., 2012) Figure 3.7 shows how this build up of helices.

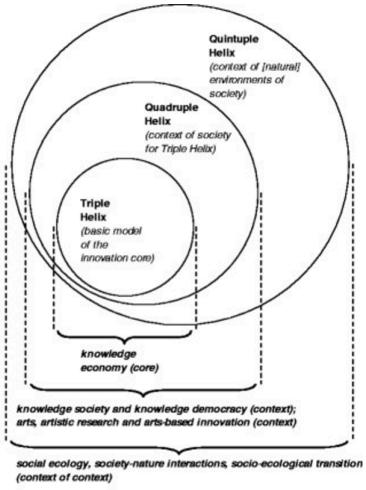


Figure 3.7: The Quadruple and Quintuple Helix innovation systems in relation to society, economy, democracy, and social ecology (Carayannis and Campbell, 2014)

The Quintuple Helix is prone to creating a mutually beneficial situation for ecology, knowledge and innovation, while creating synergy between economy, society and democracy. The objectives of the Quintuple Helix seem directly in line with the objective for this research project that aims for responsible innovation. However, to not further complicate the already complex combinations that the Quadruple Helix exposed, the Quintuple Helix is not considered in the proposed framework for responsible innovation systems. The reason that it is specifically mentioned and explained here is because in future research the framework might be extended from a responsible innovation framework to a truly sustainable innovation framework that is in line with ecology too. Still, the Quintuple Helix as defined by Carayannis and Campbell, contributes to this thesis with the conceptualisation of different types of capital that each helix is producing. Figure 3.8 shows the dynamics of the system. The five helices each generate a different form of capital, namely political, economic, social, human and nature capital. Whenever an organisation creates multiple types of capital, it becomes an intermediary within this complex knowledge system. Throughout this thesis, these different types of capital will be extensively used to describe 'value creation' by each helix, or institution.

In reaction to these additions, Leydesdorff (2012) tried to explain the possible algorithmic extension of the TH with a paper on the N-tuple of helices. This would allow a researcher to construct their own dimensions, such as the media- and culture-based public and the natural environment. However, in the paper itself, the dimension that is elaborated on is the addition of a spacial dimension, opening the helix

up to global configurations. Leydesdorff warns that adding such dimensions requires specific design of suitable indicators and should only be pursued if the three basic dimensions have not proven sufficient. Leydesdorff et al. (2014) have additionally created a programme that can be used to calculate synergy between up to four helices.

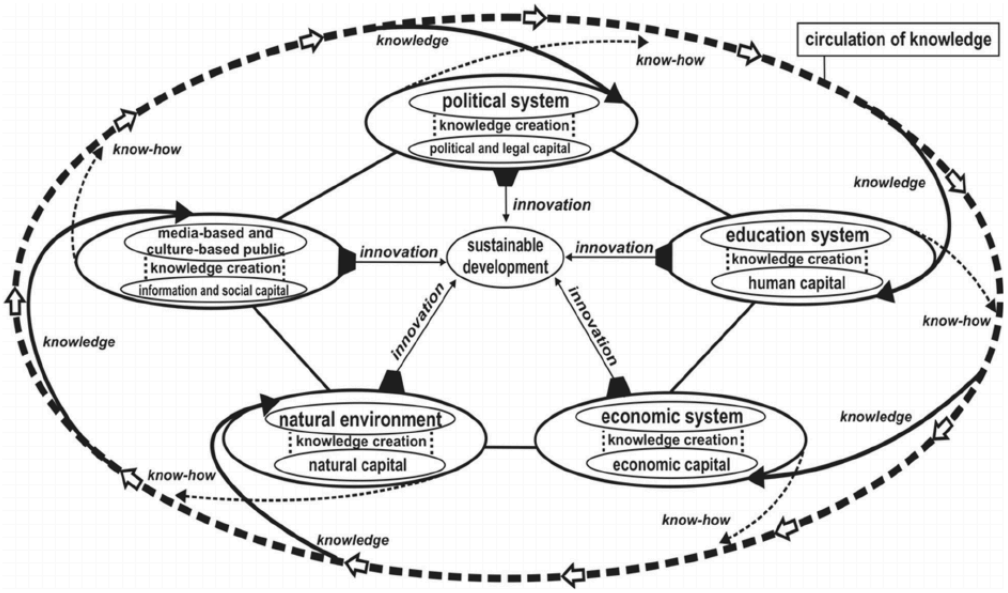


Figure 3.8: The Quintuple Helix model and its function (functions) (Carayannis et al., 2012)

Figure 3.8 shows a complex knowledge system in the form of the Quintuple Helix, where the flow of knowledge creates fractal and non-linear patterns. It naturally requires organisations to be able to deal with knowledge flows that cross their own boundaries. What happens at those boundaries and what the implications are for internal processes that this openness will produce is, however, not completely covered by the Triple, Quadruple or Quintuple Helix. Therefore, a better understanding of what a free flow of knowledge does with an organisation is needed, which is sought in the theory of Open Innovation.

3.2.3. Open Innovation

One of the most recent and most rapidly developing topics in innovation management is Open Innovation (OI). The interest in Open Innovation spans many disciplines from economics to psychology and has moved governments to adjust their policy frameworks to OI. (West et al., 2014) Chesbrough introduced Open Innovation to the world. (Chesbrough, 2006) However, it consist of elements that are not new in itself, such as absorptive capacity, complementary assets and exploration versus exploitation. (Dahlander and Gann, 2010) (Huizingh, 2011) Opening up the innovation process of firms lies at the base of the OI perspective where one of the most frequently used definitions is: *'A distributed innovation process based on purposely managed knowledge flows across organisational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organisation's business model'.* (Chesbrough et al., 2014) Political, human and social capital are clearly examples of non-pecuniary mechanisms. Open Innovation can be understood as the contrary to the traditional internal R&D practices, after which the findings are commercialised by the firm itself, or closed innovation. In Open Innovation, the R&D process, or design stages, are open to influences of outside knowledge partners. It can allow for both internal knowledge to flow to the outside *(outbound)* as outside knowledge to flow inside *(inbound)*. Figure 3.9 gives a graphical representation of this.

Open Innovation was introduced with the intention to change current practices in managing, by showing firms how to cross their boundaries in innovation creation and commercialisation. This is particularly relevant in this thesis, where innovation on rural energy technology is reliant on these boundary-

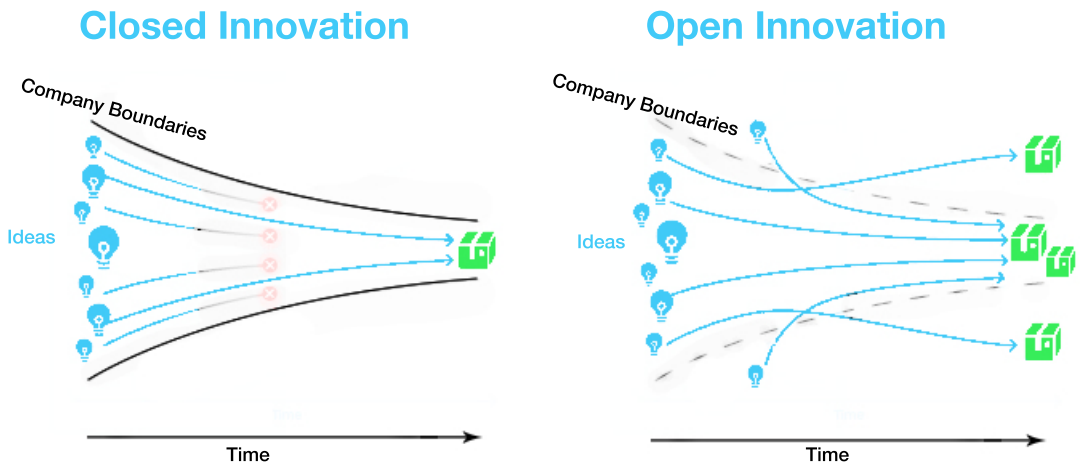


Figure 3.9: Closed Innovation versus Open Innovation

crossing processes, as was also seen in former sections. Furthermore, Open Innovation is explicitly mentioned as a tool for Responsible Innovation, specifically inclusion, in the initial paper proposing the framework. (Stilgoe et al., 2013) Also in Section 3.1.3 it was shown that open knowledge networks might facilitate Responsible Innovation in systems, therefore the relevance of Open Innovation in the Responsible Innovation context should be clear.

Several preconditions exist before Open Innovation can become successful. Organisations must be aware that there is an open environment and understand its potential value. They must thoroughly examine their external contacts, ensuring that there is mutual trust and all risks are known. Also sufficient communication structures must be in place. (Westergren and Holmström, 2008) Furthermore, Open Innovation activities are dependent on the availability of external knowledge, making it necessary that a functioning innovation system is in place. (Wang et al., 2012)

Empirical Evidence on Open Innovation

A number of quantitative empirical studies have provided valuable insight in the benefits and limitations of Open Innovation. Spithoven (2013) showed it can be suggested that an open innovation process is usually resulting in stronger innovators. For SMEs it is often argued that a lack of resources is a barrier to perform Open Innovation, while at the same time this argument is also used as an argument why looking outward should be pursued. In a different paper, Spithoven finds the role of Open Innovation for SMEs, compared to bigger companies, to be of a larger influence. The SME's dependence on Open Innovation is larger, because of a higher intensity of Open Innovation practices per employee. In an economy of scale environment, however, SMEs benefit more from a protection of intellectual property then larger companies do. Still, it is also found that SMEs with an Open Innovation environment generate more innovative products and services than larger companies with open environments. This shows that there are two sides of the coin to Open Innovation. A company must balance their Open Innovation practices carefully, in order not to get downplayed in terms of giving away to much information. Other research by Laurens and Salter also shows that limitations to Open Innovation benefits. (Laursen and Salter, 2006) Again, the research finds that firms with Open Innovation practises tend to have more innovation happening. However, they also state that openness is not without it costs. The term over-search was introduced, a situation where too much effort and reliance is put on the external sources, draining the internal resources significantly. It means there exists an (reversed) U-shaped curve regarding Open Innovation. To little Open Innovation is bad, but also too much Open Innovation is bad. However, being in the middle can generate tremendous beneficiaries. Lastly the research shows that where radical innovation is required, a firm should draw an extensive information load from a few selected experts in the field, while when the technology matures and the expertise grows, a wider search of external parties is required to stay productive. In other words, the more radical an innovation, the innovation processes should only be opened up after some experts have been around in the beginner

phase. Research by Faems et al. (2010) especially shows that in the long run Open Innovation generates financial benefits, but will have a negative balance on short the short term, allowing managers to make better decisions when short term negative financial balances are not an option. Empirical evidence by Michelfelder and Kratzer (2013) also finds that a semi-open structure is more effective in innovation acceleration then a fully open environment.

The U-curve shape of Open Innovation shows interesting similarities, or even parallels, with research explained by MIT professor Alex Pentland in his book 'Social Physics'. He shows that there exists a U-curve, where idea flow in social structures is held against creative and productive performance. He speaks of a so called echo-chamber, where over-connectivity and over-reliance has a sub optimal effect compared to medium connected nodes that kept individual paths. (Pentland, 2014) Where the given argument against over-search is that of too high costs, Pentland shows that there might be other fundamental dynamics at play in social networks. His tremendously interesting work on social structures and human behaviour is especially relevant for any researcher in the field of innovation and knowledge flows.

For a more extensive grab of empirical evidence on Open Innovation, a review by West and, among others, co-authored by OI guru Henry Chesbrough, gives a summary of all the important findings that support the Open Innovation theory, as well as exposing its limitations from multiple perspectives. (West et al., 2014)

Inbound & Outbound Knowledge Transfer

Knowledge can be inward (inbound) and outward (outboud). A valid question is if inbound and outbound knowledge show different performance results for innovation. Caner et al. (2014) have tested this difference in comparison to an organisation's centrality in R&D alliances in the biopharmaceutical industry. The researchers claim that their findings are can be generalised for knowledge intensive industries, making it relevant for energy technologies as well. Figure 3.10 shows results from their research. It brings to light that a higher inbound knowledge transfer is always favourable in respect to differences in centrality and outbound knowledge transfer. It also shows that a higher outbound knowledge transfer is only favourable whenever there is a high inbound knowledge transfer. More interestingly, in the case of a high centrality and low inbound knowledge transfer, a high outbound knowledge transfer has a significant more negative effect on invention compared to a low outbound knowledge transfer. In more simplifying words, do not expect to win a game of poker, if you are the only one showing your hand. This is an insights that will become relevant later on in the results of the case study.

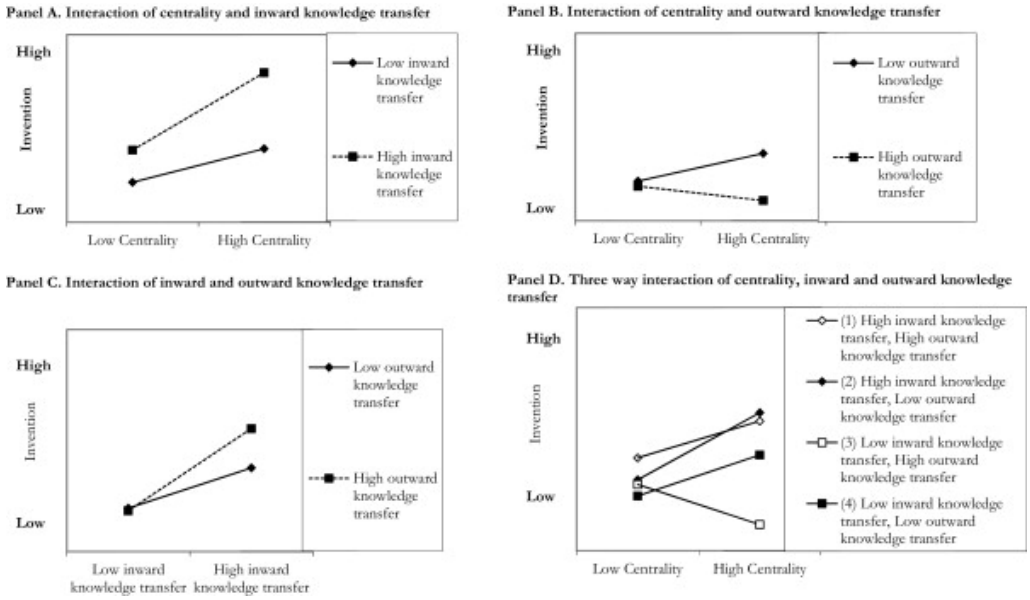


Figure 3.10: Two and three way interactions of inward and outward knowledge flow to centrality with invention as dependent variable (Caner et al., 2014)

Open Innovation in Emerging Economies & India

Another relevant question is if Open Innovation also works in emerging economies, where knowledge clusters are generally less developed. Evidence from Peru shows that also there companies with OI practises show higher sales rates. (Chaston and Scott, 2012) More relevant research, that takes India as a data input, finds something interesting regarding the openness of companies to scientific external knowledge. (Kafouros and Forsans, 2012) Whenever foreign scientific knowledge is used, performance of the firm is increased significantly. However, the study finds that domestic scientific external knowledge has a negligible effect on a firms performance. Together with the costs of openness to external knowledge, this will result in a negative effect for the firm, and from a strategic view should therefore be prevented.

Other research in India has found what types of collaborations, relating Open Innovation knowledge flows, manufacturing companies are having in several industries, including the power sector. (Tripathi, 2016) Table 3.2 is derived from the collaborations described in that paper, where the collaborations in the power sector are marked in bold letters. It shows that the examined power sector companies do not have outbound activities. The collaborations that do exist, are mainly based on efficiency increase of operations, instead of true innovation purposes. The authors make a claim that the lack of opening up of the power organisations, despite government activities, is due to the weak intellectual property regime in the country and to closed organisational structures. It seems that it is time for the Indian power sector to open up.

Table 3.2: Collaboration types found in Indian manufacturing companies (Tripathi, 2016)

Inbound	Outbound
Technology buy-in	Research project for university
Company buy-in	Immersion program
Technological know-how arrangements	Co-creation with academia
Joint ventures	Opening facilities for entrepreneurs
Open R&D centres	Innovation centre in university
Collaboration with alliances	Technology sales
Idea contests	
License technology	
Partnership with local government	
Partnership with NGO	
Independent innovation unit for sector	
Technology sourcing	

Vgrovic argues that SMEs in developing countries face several barriers, like the absence of sufficient knowledge producing entities. A framework for development on technologies was proposed, that aims to include collaboration in a structured approach for different phases in the design process. (Vrgovic et al., 2012) The framework was tested in several developing nations and was validated with a qualitative study. Figure 3.11 gives a visualisation of the framework. The framework lays out an important central role for a governmental organisation that is assigned certain roles in communication, mediation and connection between the parties. A side note given to this is that the government often proves unwilling or unable to take on this role. In India, however, there are already organisations that have been assigned a similar role in the form of the State Nodal Agencies, as will be discussed in Chapter 5. It only rests the SNAs to fulfil their roles as described and SMEs could benefit immensely from their participation. It might be argued that this framework is of interest, even though the researchers specifically name India as an exception to several important barriers, such as the presence of big transnational organisations. The bottom up nature of rural energy technologies, however, has until now seen little interaction with larger companies, presumably due to the lack of opportunity for the easy deployment of large volumes of products.

Interaction of Knowledge Flows with the Public Sphere

What appears to be absent in the framework of Figure 3.11 is a consistent interaction with customers, only indirectly through the market agency. From there no interaction is seen anymore, while responsible

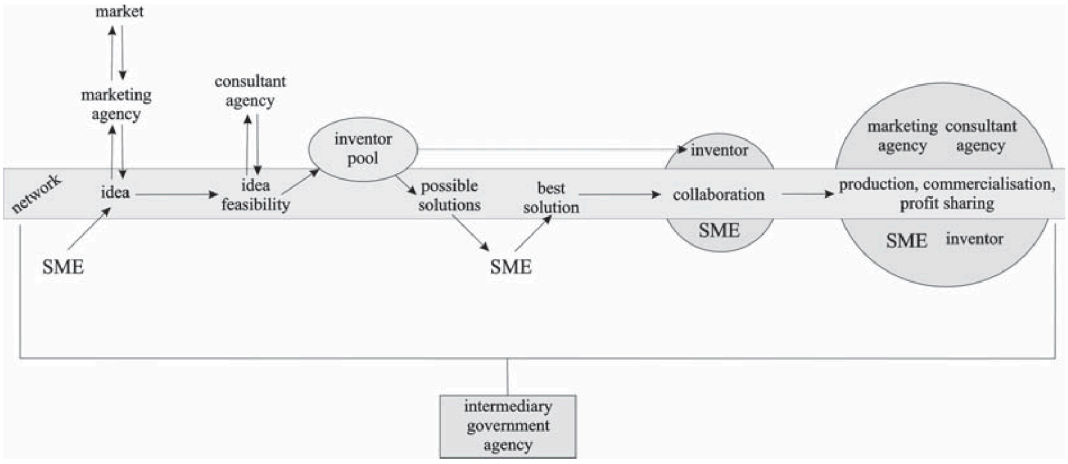


Figure 3.11: Joint Invention Market Model for SMEs engaging in Open Innovation In Developing Countries (Vrgovic et al., 2012)

innovation arguably requires a more thorough inclusion of the public in the design process. Getting inbound knowledge from customers has, however, been proven to be difficult, because most organisation seem to have failed trying to establish it, as found by Dahlander and Piezuka. (Dahlander and Piezunka, 2014) They also came up with the best practices in getting suggestions from customers, derived from successful companies in an analysis of 24.000 initiatives. They find that *'proactive attention'* (submitting internally developed suggestions to externals to stimulate debate) and *'reactive attention'* (paying attention to suggestions from externals to signal they are being listened to) are important to get response, especially when the people in the target group are newcomers to the product. A more in depth approach to a customer knowledge management system, also incorporating social media feedback and customer discussions is proposed by Ziemba and Mullins, explaining different phases in the process. (Ziemba and Mullins, 2016) It must be noted that the research is, as said by the researchers themselves, one of the first of its kind and has used the country of Wales as a reference, which has a more developed civil society. (Ziemba and Mullins, 2016)

However, there lies another role for the public in the future that needs to be considered. Udo Pesch describes this in what Van Der Veen calls, the *producer's society*. (Pesch et al., 2010) Especially in energy technologies, the public can more often take the role of a *prosumer* (from producer and consumer). Whenever a villager owns a solar panel, he can share his excess of energy with neighbouring households, for example by letting them charge their mobile phones against a fee. This allows for villagers to create their own business models and increases their dependency on the product that should serve their expectations and requirements. It can be argued, that including prosumers in the design process might even decrease the gap that exists between an Energy Service Company (ESCO) and the customers of energy, because the prosumers are more likely to speak the 'language' of the villagers when they experience certain problems. Ziemba and Eisenbardt have investigated what kinds of interaction exist with between prosumers and the product developers and have come up with a framework of types of participation of prosumers. They conclude that there lie opportunities in development, marketing, delivery and customer service activities for prosumers to contribute. (Ziemba and Eisenbardt, 2015b) (Ziemba and Eisenbardt, 2015a) These findings suggest that the framework of Figure 3.11 is not yet sufficient to include prosumer interactions in energy technology development in the rural areas of India.

Difficulties with Open Innovation

Some limitations to Open Innovation have already been addressed, such as over-search and the negative effects of a high outbound knowledge flow pared with a low inbound flow, while being in a central position in the innovation system. Additionally, the shortly addressed difficulties with Intellectual Property (IP) management is not only a problem in India, but a returning problem for companies that are sharing knowledge. Again companies do not want to show their cards, if there is no win for them in the funnel. Gambardella and Panico have tried a mathematical approach towards allocating IP rights,

however their functions have only one party with decision rights and only leave room for two parties to collaborate. (Gambardella and Panico, 2014) IP is difficult, because it is on the one hand impossible to determine each party's contribution at forehand and determining it after the design process is prone to bias of both parties, wishing to gain the best deal out of it. Until today, the IP problem in Open Innovation environments does not seem to be solved.

Furthermore, the research that focuses on how Open Innovation behaves in larger ecosystems and communities, such as developed systems of innovation is rather limited. It has been found that such networks allow firms to accelerate value creation, however the effect on only value caption is harder to find. (West, 2014) It is argued that the governance of such ecosystems is different compared to dyadic (two-party) OI. (Nambisan and Sawhney, 2011) Adner states that the connection between Open Innovation and innovation systems has broad potential for future research. (Adner, 2006) Especially the availability of social networks analysis, that can show how social capital can shape Open Innovation, should be exploited. (West et al., 2014) In applying OI insights to innovation systems, this thesis goes on fairly uncovered grounds. It is, therefore, necessary to get a bit deeper in what all mentioned theories have in common, have complementary to each other and how they can contribute to responsible innovation systems.

3.3. Summary & Discussion on Responsible Innovation Systems

Chapter 3 has tried to answer the question: *What is a responsible innovation system?*. It is clear that the scientific world does not yet provide the definite answer, because the definition of a responsible innovation system was not found. By dividing the question into halves, another approach was taken in synthesising an answer.

The first half is to answer what responsible innovation is in respect to a collective innovation process. It was shown in Section 3.1 that the framework of Responsible Innovation addresses the guidelines that see to an anticipatory, reflexive, inclusive and responsive behaviour while making design decisions and reacting to changes in society. Inspired by Scholten and Van der Duin (2015) it is argued that the RI framework is suitable for the use in small firms. Van Der Duin confirmed this might be assumed for the case of small social enterprises in India in a personal meeting. It was also found that the groups of stakeholders to who responsibility might be accounted, do not change over time, while their interests and influence do might change. Looking to systemic responsibility, responsible innovation systems were most likely found to be open knowledge networks. (van Geenhuizen and Ye, 2014) Therefore, responsible innovation in the collective innovation process was specified as the application of the intertwining dimensions of anticipation, reflexivity, inclusion and responsiveness in an evolutionary environment with actors of an innovation system that contains a constant group of institutions, while an open knowledge environment is present.

The second half answered what an innovation system is. Here the literature has given an extensive range of possible descriptions of what an innovation system can consist of. The theories of Systems of Innovation , Triple & Quadruple Helix and Open Innovation were chosen to be examined further for a possible contribution to a framework for responsible innovation systems, because of their consideration of different innovator types. Table 3.3 gives more insights in what each theory brings to the table in contributing to the dimension of responsible innovation so that also a responsible framework might emerge from them.

Table 3.3: How each discussed theory relates to the RI dimensions

	Anticipation	**reflexivity**	**Inclusion**	**Responsiveness**
SI	-	X	X	-
TH	X	X	/	X
4H	X	X	X	X
OI	-	-	X	X

Systems of Innovation (SI) has a clear description of the components, relations and functions of an innovation system, creating ways to reflect for actors on what position they are taking and ways to include the other actors of the process. However, System of Innovation is static and fails to address changes in the system, lacking responsiveness and anticipation.

Triple Helix (TH) does give a more evolutionary approach to innovation systems because it expects

a system to change and evolve, making it add to the dimensions of anticipation and responsiveness as well. It creates the capacity to expect and manage on changes in the system, such as an increase of decrease of the influence of one of the spheres with corresponding overlapping actors. However, triple Helix fails to include a civil society actor, lacking full inclusion in the eyes of many researchers.

The extension to the Quadruple Helix (4H) completes inclusion, because of this additional institution of civil society, while also having the characteristics of the Triple Helix that show anticipation, reflexivity and responsiveness.

Open Innovation (OI) does not so much describe a system, but the relations within systems. It promotes inclusion of all stakeholders and by sharing knowledge one can become more responsive to situations where new knowledge is needed to innovate. However there is little anticipation and reflexivity promoted by the theory itself, because their are no future visions determined or roles defined according to a specific framework.

If one would only follow Table 3.3, it could be argued that the Quadruple Helix can be confidently used as a framework for responsible innovation systems. However, certain additional advantages and disadvantages could be presented as well. It exposes other sides to the theories that need to be considered and are shown in Table 3.4.

Table 3.4: Advantages and disadvantages of relevant innovation frameworks

framework	**Advantages**	**Disadvantages**
SI	- Shows factors of innovation - Definition of components, relations, functions - Regional focus is beneficial - Possible extension to Clusters	- Unclear definitions of boundaries - Lack of evolutionary dynamics - Insufficient consideration of international influences
TH	- Evolutionary dynamics - Institutional division of actors - Allowing of other explanatory frameworks as subsystems	- Lack of sufficient description of relations - Lack of sufficient consideration of IP - Embedded in civil society, rather then a separate institute
4H	- Additional geographical dimensions - Additional institutional dimensions - Allows for taking into account of knowledge society	- Fairly new and lack of empirical evidence - Difficult to define the extra helices
OI	- Thorough analysis of relations - Empirical evidence is available - Available framework for design process	- Lack of sufficient consideration IP - Little known on OI in large networks

All theories seem to have some advantages that suit the objective of this thesis, but they also contain a set of disadvantages that prevent them from being completely applicable. So will the 4H not allow for specific relations to be examined, something that is going to be crucial in determining the responsibility of a system. It quickly becomes apparent that parts of the models are complementary to each others shortcomings. This calls for a combination of the theories for formation of a Responsible Innovation Systems framework.

The way towards a combined approach of innovation frameworks is already being suggested. Fromhold and Werker came to a conclusion that Triple Helix and Regional Innovation Systems (RIS) should be combined in their attempt to determine the optimal role of universities in society. (Fromhold-Eisebith and Werker, 2013) Therefore, the line of argument in this discussion is one not uncommonly found. More combinations have been suggested, combining OI and TH (Villarreal and Calvo, 2015), SI, TH and 4H (Ivanova, 2014) and OI, RIS and TH. (Kerry and Danson, 2016) Especially Kerry and Danson explain that an open innovation landscape allows for the Triple Helix to emerge and the regional innovation system to develop. Finally even the relations between Responsible Innovation, OI, TH, 4H and SI frameworks have been noticed by some Italian researchers. (Distefano et al., 2016)

The only concrete combination of models, however, is that of Ranga and Etzkowitz (2013) with their introduction of Triple Helix Systems (THS), a combination of TH and SI, which was already shortly mentioned in Section 3.2.2. It will serve as the most important building block for the creation of a

framework suitable for the objective of this thesis. It is argued that the THS approach is suitable for regional innovation strategies in developing countries, where new markets, innovative goods and services for the bottom of the pyramid need to be developed.

The Triple Helix Systems framework divides an innovation system in the elements of '*components, relations and functions*'. The components represent the actors of the Triple Helix. In the relations element several options for cooperation models are given. Lastly, the functions element explains the articulation of virtual spaces where knowledge creation, innovation and consensus takes place, respectively, called the Knowledge, Innovation and Consensus Spaces. A contribution to these virtual spaces by the actors and relations means that the fundamental building blocks of innovation are performed, namely the creation of new knowledge, the combination of that knowledge towards innovation and the consensus on decision-making processes that accelerate these phenomena. Next chapter will see to a more detailed description of what these elements entail.

So what is a responsible innovation system? The following definition, influenced by Kerry and Danson, will be used throughout the rest of this thesis: *A responsible innovation system is an open knowledge network that allows for the Quadruple Helix to emerge and the regional innovation system to develop, while the dimensions of anticipation, reflexivity, inclusion and responsiveness are internally and mutually shared among the actors*.

4

The Responsible Innovation Systems Framework

What framework can be constructed to expose responsible innovation practices on a systemic level?

Now that is determined what a responsible innovation system is, the construction of a conceptual framework is done that can assess and guide an innovation system on its responsibility.

4.1. Combination of Innovation Theories

It became clear from former chapter that the theories of Responsible Innovation (RI), Systems of Innovation (SI), Triple/Quadruple Helix (TH/4H) and Open Innovation (OI) could be combined to result in a Responsible Innovation Systems framework. As was mentioned, the combination of TH and SI, proposed by Marina Ranga and Henry Etzkowitz can be a very concrete sub combination of the framework found in the literature and its structure will serve as a backbone that shall be extended further. (Ranga and Etzkowitz, 2013) In Figure 4.1 the combination of all the theories is represented visually.

In the synthesis of Ranga and Etzkowitz, the TH and SI combine towards the Triple Helix Systems (THS) framework, consisting of components, relations and functions. Regional innovation actors can be examined on their evolution, current scope of operations and future trends through the THS framework, which is in line with the objective of this thesis to assess and guide the innovation system. The components consist of the government-industry-university (GIU) actors. However, the THS framework misses the important link towards the public that is based in a modern knowledge society striving for a knowledge democracy. In the relations part, the THS tries to describe five different relational types, however these distinctions fail to resonate with a thorough description in terms of knowledge flows between organisation, that a potential integration of OI influences make more sense here. The functions part of THS constitutes three virtual interaction areas, namely a Knowledge, Innovation and Consensus Space. The Consensus Space is very suited to be extended with RI practices, for which the condition can be made that activities need to be visible that contribute to those dimensions, before a Consensus Space might form. Therefore, there will be three additions to the THS framework, the Quadruple Helix in the components, Open Innovation in the relations and Responsible Innovation in the functions.

First, the introduction of the fourth helix (4H) to the components shall be done. While participatory approach of the public is not without critiques (Rothstein, 2007), recent elections throughout the world have proven that a lack of inclusion of the public, or a sense of it, can have great impact and should be taken very seriously. But how is this fourth helix defined in a separate institution?

Ivanova resolved some conceptual worries by showing that it is mathematically possible to extend to a fourth sphere towards a, in her words: *"four-dimensional Cartesian coordinate system where four sub dynamics are spanned orthogonally"*. (Ivanova, 2014) While, originally contesting the addition of

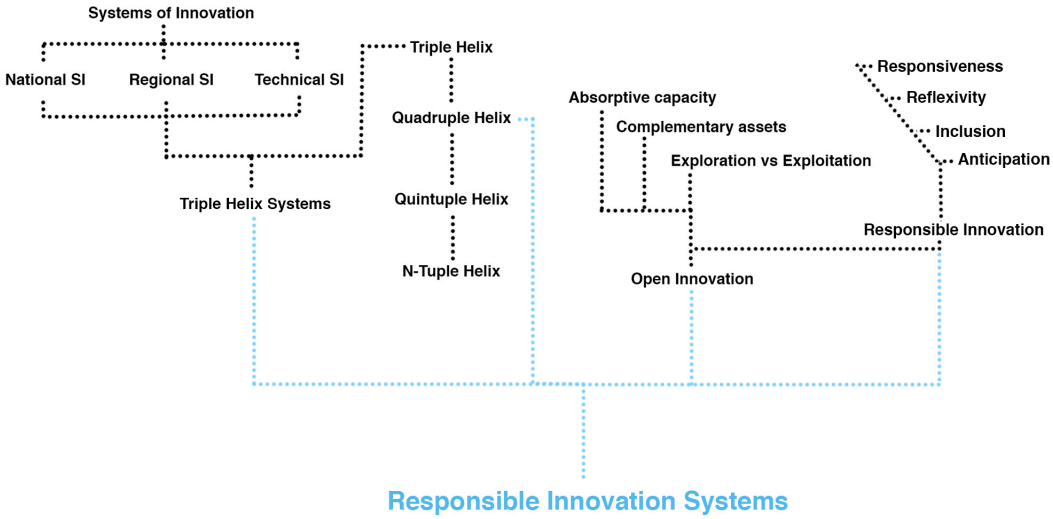


Figure 4.1: A visual representation of how the innovation theories are combined

a fourth sphere of civil society, Leydesdorff as one of the fathers of the Triple Helix himself is now working together with Ivanova in explaining this phenomenon. The Quadruple Helix should behave as an additional selection mechanism for design choices. The most mentioned form is society as a separate entity. Rieu tries to define what society actually means. (Rieu, 2011) Theoretically, he says, the 4H regulates interactions between universities, government, firms, industries and their related services. When looking at the development of cities, Cohendet and Simon note that next to the three institutions of TH, communities provide the structures that see to a successful integration of activities. (Cohendet and Simon, 2008) However, practically this must also be structured and organised. Some possibilities are mentioned such as citizen debates, on-line surveys and studies on societal needs, however, the 'public space' that is created with the 4H cannot simply be reduced to that. It is, therefore, one of the challenges of this research to determine structured public actors that represent society as an entity that are able to serve as components in the THS framework, whilst having relations and contributing to the functions.

Carayannis and Campbell tried to capture the role of the Quadruple Helix in their view of the culture- & media based public and civil society, as proposed by Carayannis (Carayannis and Campbell, 2009). Their definition of the 4H will be used during this research, because its the most prevalent in the literature. The 4H is taken as an extra 'institutional sphere' in the components element of the THS, essentially creating a 4HS framework with government-industry-public-university (GIPU) actors. The role of the Public institution is to create social capital. (Carayannis et al., 2012). An NGO that aims to create woman empowerment through energy access is therefore a clear social capital creator and will be considered a public/civil society actor. A social enterprise who aims to create both social and economic capital by providing energy access to rural poor and generate a profit at the same time, such as Rural Spark, is defined as an intermediary Industry-Public (IP) actor. Furthermore, an additional argument that the Quadruple Helix extension of Carayannis and Campbell contains reason can be given. They introduce Mode 3, which is the knowledge production model that allows for the Quadruple Helix to exist. It shows certain characteristics that highly resonate with the functions of the THS framework, because of the mentioning of knowledge clusters and innovation networks. This can be seen as parallel to the Knowledge and Innovation spaces in THS. Furthermore, the Quadruple Helix extension was proposed in order to be representative of an open innovation society, highly resonating with the next addition as well. Distefano et al. (2016) The Responsible Innovation dimension of inclusion is completely covered by the components element, because it shows which stakeholders are involved and which are not. The components are further described in Section 4.2.1.

Secondly, the framework is enriched with insights from the concept of Open Innovation in the relations element of the framework found in Section 4.2.2. The second addition essentially creates an Open Quadruple Helix Systems framework. In Section 3.1.3 it was seen that a responsibility in innovation systems is facilitated by an open knowledge network. With Open Innovation, the directions of knowledge flows through the organisations, to or from partners, can be more thoroughly understood. The relations element of the framework is therefore completely filled in with Open Innovation influences. It can be examined whether a relation or partnership is involving inbound or outbound knowledge flows and what types of knowledge flows (political, economic, social or human capital) are circumventing in the system. Ultimately, both inbound and outbound knowledge flow should be present, creating a two-way knowledge channel. Systemic innovation is unknown territory for Open Innovation literature and therefore, this research will enrich the understanding of Open Innovation dynamics in large networks.

Thirdly, the functions of the framework are extended with the remaining dimensions of Responsible Innovation, namely anticipation, reflexivity and responsiveness. It is further explained in Section 4.2.3. The main function of the framework becomes: **Responsible generation, diffusion and use of knowledge and innovation, which is realised through articulation of the Knowledge, Innovation and Consensus Spaces**. A condition is added, that the Consensus Space can only form if there are activities visible that contribute to the dimensions of anticipation, reflexivity and responsiveness. The dimension of inclusion is already covered by the components element. This third and latest addition creates the Responsible Innovation Systems Framework.

The combination of all relevant tools has resulted in a framework that is, in theory, capable of ensuring that the pillars of responsible innovation can be followed in innovation systems. Anticipation, because of an expected changing environment, derived from helix literature. Inclusion, through the consideration of all components of the 4H, SI and OI. Reflexivity, with the careful analysis of the different knowledge flows that institutions create and what each role in the system is. Responsiveness with the capability of the 4H to have evolutionary dynamics that allows the organisation to change and take on different functions in case of gaps and the influence of OI on responding to external knowledge in open networks. The four pillars of RI can furthermore be strengthened in the conceptualisation of the Consensus Space, where activities contributing to anticipation, reflexivity and responsiveness within and among actors are promoted.

4.2. The Combined Responsible Innovation Systems Framework

Figure 4.2 gives a synthetic representation of the Responsible Innovation Systems framework, adapted from the Triple Helix Systems from Ranga and Etzkowitz (2013) by adding the public, or civil society, as a fourth helix, insights into two-way knowledge flows by Open Innovation and Responsible Innovation practices in the functions of the framework.

The Responsible Innovation Systems framework consists of 3 elements: Components, relationships and functions. Components are represented by the Quadruple Helix and can take hybrid forms of multiple institutions. Relations aim to expose two-way communication and knowledge flows. The function of the framework is to responsibly generate, diffuse and use knowledge and innovation and is embodied in the creation of the Knowledge, Innovation and Consensus Spaces, each with its specific role of explaining interaction in the system and with the condition that activities contribute to the dimensions of anticipation, reflexivity and responsiveness, so that the Consensus Space can form.

4.2.1. Components

The element of components essentially sees each actor in the system as a component and addresses certain characteristics to it. The influence of the quadruple helix becomes relevant here, using the four institutions of Government, Industry, Public/Civil Society and University/Academia. The components element effectively shows the inclusion of each institution in the collective innovation process.

However, for the data collection method of the construction phase of the collective innovation process that will be explained later on, the components element can be extended. It gives four extra characteristics to an component:

- Single-sphere and multi-sphere organisations, also hybrids or intermediaries

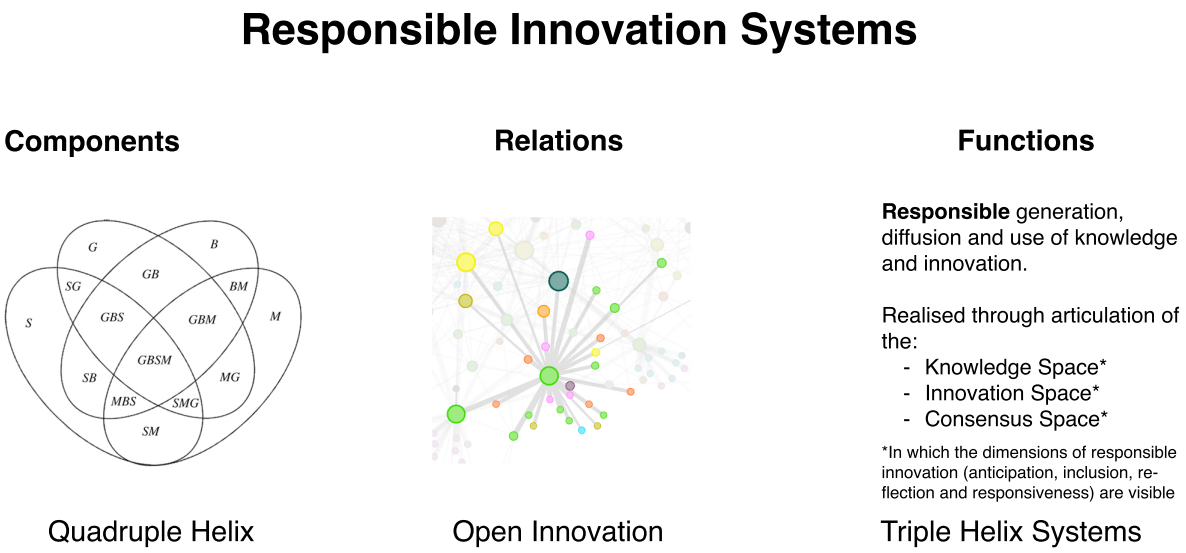


Figure 4.2: A synthetic representation of the Responsible Innovation Systems Framework

- R&D and non R&D innovators
- National or international
- Fully or partly focused on the technology

Single-sphere and multi-sphere (intermediary/hybrid) organisations

With the transition to a knowledge democracy, accelerated by the Internet as an ever increasing source of free information, a distinction between knowledge producing entities in the form of institutional spheres is helpful. Following the Quadruple Helix (4H) the distinction is made between the institutions of Government, Industry, Public/civil society, and University/academia (G,I,P,U). Each of these institutions follows a certain set of rules that usually governs design choices. Often they have a different set of goals, roles, values and resources. Certain organisations specifically follow the institutional rules and stay within the boundaries of their institutions, such as classic university models or governmental agencies.

However, as is the influence of the Helix theory, organisations can also cross boundaries and start behaving more according to the rules of other institutions, therefore making important bridges between them and increasing knowledge flows. These are the multi-sphere, hybrid or intermediary organisations. Examples are the technology transfer offices in universities, social enterprises, governmental research organisations and technology incubators. Generally these actors have a more responsive organisational structure and permeable boundaries. (Etzkowitz, 2012) So it could be argued that an innovation system is more responsive if it contains more intermediaries and therefore more responsible. Following Figure 4.2, one can see the possible configurations of multi-sphere actors or collaborations. The importance of intermediary organisations is also mentioned in respect to developing countries, where these intermediaries need to fill the gaps of under-performing spheres. (Szogs et al., 2009)

To make the institutional distinctions clear, four levels of organisational configuration are defined. Level 1,2,3 and 4, which each number representing the number of institutional dimensions that are present within an organisation. Those dimensions are filled from the variables G, I, P and U, as can be derived from Figure 3.6, all together creating a total of 15 possible configurations.

R&D and non R&D innovators

This distinction is based on the observation that innovation is not only based on R&D practises. Even though explicit knowledge creation is of utmost importance, especially in knowledge intensive technologies, tacit knowledge can not be underestimated. Next to R&D, other factors for innovation are intangible resources, new combinations of existing knowledge and processes or organisational and market innovations. While traditional R&D organisations, such as (governmental) research groups and company R&D departments are fairly evident, the public sphere can also be seen to create social capital as a product from social cohesion in communities, human rights or from the creative industries in the form of the arts. Berlin's liberal attitude towards street-art is a good example from this created social capital, which originated from the separation of the city through the Berlin wall. The west part of the wall, which was considerably more free during that time, used the wall as a canvas and as a form of protest against the atrocities at the other side. This form of social capital was one of the factors of change and is recognised until today by the tolerance of the city against modern graffiti. (Arms, 2011)

Non-R&D innovators can be organisations that work on production, marketing, sales, personnel training and competence building, financing, technology. This is not confined to the institution of Industry, but can be seen everywhere. As soon as there is no internal novel explicit knowledge production, an organisation is classified as non-R&D.

National or international

The next characteristic of components in the construction phase is to determine the geographical distance from the innovation system. Many organisations nowadays have transnational activities, but have the headquarters far from where the action is really happening. 'Is geographical proximity necessary in the innovation networks in the era of global economy?' This question was addressed by Rallet and Torre (1999). They state that it is widely accepted that the different actors of innovation need to be physically near to each other because the transfer of tacit knowledge can only happen through frequent face-to-face relations. However, in addition to that, they find: "Non local relations appear as a key factor to develop innovation. As a conclusion, non local relations should be encouraged by local development policies in the same way as local relations." Therefore this characteristic tries to differentiate between local and non local relations. It is assumed that whenever an organisation has its headquarters outside of India, it counts as a non local organisation, even when there is an Indian department present. This comes from the impression that knowledge still needs to come from abroad, before it can get to the regional department and often the regional departments do not decide on their own operations and activities. From the above insights, an innovation system that has a good balance of international and national actors appears to be more responsive.

Fully or partly focused on the technology

Actors that are part of the innovation system of rural energy technology, do not necessarily have this in their direct objective and might span many more innovation systems. Universities might have some research projects, but the overall organisation focuses on much more. The same with the government, for example, the Central Electricity Regulatory Committee directly influences decisions made on policy for rural energy technology, but at the same time might decide to benefit urban areas more, leaving rural areas behind. Whenever an organisation is fully devoted to energy access, or rural energy technology, one can be more sure that its activities are always focused on benefiting the innovation system. If the network of relations of an organisation does not contain partners that are fully devoted to the system, it might mean that they are vulnerable to shifting priorities of their relations and, therefore, less responsive.

4.2.2. Relations

The relations element of the framework relates to the influence of Open Innovation. As seen in Section 3.2.3, knowledge flows can be conceptualised as inbound and outbound across the boundaries of an actor. In order for full responsibility to be reached, both ways of knowledge flow should be open, since otherwise the dimensions of anticipation, reflexivity and responsiveness can not be accordingly articulated between actors. It is therefore that the relations elements in the framework will show if these two-way knowledge and communication channels are opened up, so that a collective innovation process can happen.

As with the components element, for data collection methods of the construction phase, the characteristics can be extended for the relations element. The strength of the relation can be measured, to partly determine the speed of knowledge going through the network. The year of the start of the relation can be determined to show the evolution of the network. Lastly it can be shown what type of connection exists between components. Ranga defines five different types of relationships, namely: *Technology Transfer, Collaboration and Conflict Moderation, Collaborative Leadership, Substitution and Networking*. It is valuable to make this distinction, however for the purpose of this research that distinction is not sufficient, because it is unable to describe the different types of knowledge flows in the network. The focus will be, therefore, much more on the contribution of different relations to the specific functions of the framework, which are the spaces of Knowledge, Innovation and Consensus, explained in Section 4.2.3. For each relation that is researched, the specific contribution to either of those spaces shall be determined and in addition it might be said whether the relation contains some form of funding.

4.2.3. Functions

The function of a responsible innovation system is responsible generation, diffusion and use of knowledge and innovation, which is realised through articulation of the Knowledge, Innovation and Consensus Spaces. The virtual spaces are defined, each with its specific role of explaining interaction in the system. The spaces specifically arise at boundaries between institutions, however intra-institutional collaborations are also found to contribute to the spaces. One of the conditions to come to responsibility in the system is to ensure that the RI dimensions of anticipation, reflexivity and responsiveness are found to be enhanced by activities of components and their relations, whereby creating the Consensus Space.

Knowledge Space

The Knowledge Space is meant to expose the generation, diffusion and use of knowledge by the components of the innovation system. It allows for the resource that knowledge has become to be conceptualised in a knowledge society or democracy. Generally, a mature Knowledge Space is composed of a diversified set of actors that have strong knowledge sharing interactions and several novel knowledge production actors that are interconnected, where a rather free flow of ideas is present. For every actor it can be determined if its knowledge base is either small or large and in what ways it is sharing its knowledge with its relations and if these relations are of a diverse enough institutional configuration. Also, a shared creation of knowledge between those actors might be determined.

Innovation Space

Innovation is essentially the combination of knowledge sources into new products, services and processes. Innovation Space formation supposedly happens most at the boundaries of the institutions, where entrepreneurial activities can exploit opportunities. Examples of strong elements of innovation spaces are science centres combining with start up incubators and business centres or venture capitalists. Another interesting example of the creation of an innovation space was the initiative of the New York City zoning authority that transformed the decayed industrial neighbourhood of Soho to a hot-spot of the creative industries, by allowing professional artists to move into old industrial building for low rents. For this research, the innovation space shall be conceptualised as contribution by relations that see to combine knowledge into new products, services or processes, such as shared research projects or shared product developments.

Contribution of relations to Knowledge and Innovation spaces

What was not specified by Ranga and Etzkowitz, but is clearer defined here, is that the relations can contribute to the spaces. To clarify, an example is presented with two specific industry-university interactions. Both "*Shared R&D project*" and "*R&D buy-in*" could simply be seen as IU interaction in the helix theory. However, it was shown in Section 3.2.2 that the economic benefit between the two varies substantially, thus making them fundamentally different. The contribution to the spaces allows for a better analysis of the differences between these types of relations, relating more to the effect it has within and towards the system of innovation. R&D buy-in only contributes to the Knowledge Space, as created knowledge in the academic institution is simply just transferred towards the industrial institution. For innovation to take place, another activity needs to happen internally, so the R&D buy-in does not contribute to the Innovation Space. A shared R&D project, however, contributes to both

spaces. The Knowledge Space, because of knowledge creation. The Innovation Space, because of the combination of different types of knowledge from the institutions. However, this does not yet tell anything about responsibility of relations in the system.

Consensus Space

The Consensus Space is the space that should expose systemic responsible innovation activities, or perhaps the other way around. The Consensus Space is where components are brought together and define shared goals, compare values, determine roles, sketch scenarios, create resources or in simpler words, build bridges towards sustainable cooperation. The relations and activities between actors shall show if they have any form of consensus establishing in those connections.

Ranga and Etzkowitz (2013) explained the Consensus Space from their perspective. Often it is the government taking a leading role in this, however, this does not have to be always the case. It is the interactions between several institutions that define problems, builds up consensus on solutions, while consolidating conflicting interests. (Kuhlmann, 2001) In the Consensus Space, organisations realise that a larger interdependence exists, where they are only part of a greater whole. Also the Consensus Space is seen as a catalyst between the Innovation and Knowledge spaces, where in its absence, most likely valuable opportunities and advantages are overlooked. This does not mean that a region can only be productive in terms of innovation whenever a Consensus Space is formed from the start, as the analysis from Ranga of Silicon Valley shows, where only in the last stage of the regional development a Consensus Space was formed. However, in order to reach responsibility a mature Consensus Space is required, as is argued here.

For this research, the Consensus Space is conceptualised in a slightly different manner. A mature Consensus Space is the result of a systemic responsible innovation process, where the dimensions of anticipation, reflexivity and responsiveness are mutually shared in open knowledge and communication channels among stakeholders that include all components of the quadruple helix. It means that, for example, activities to come to anticipation, reflexivity and responsiveness are done together with partners, or the results of those activities are shared with them. This can, therefore, only happen if two-way communication channels exist that allow for inbound and outbound knowledge flow, while full inclusion can only be reached if all Quadruple Helix institutions are present in the partners.

The degree of RI in the construction phase of the collective innovation process can be determined as the percentage of relations that are contributing to the Consensus Space. This shall become relevant in one of the data collection methods in Chapter 6 and is further explained in next subsection. A contribution to the Consensus Space is done when a relationship is responsible. A relation is responsible when it incorporates anticipation, reflexivity and responsiveness. The tools specified by Stilgoe et al. (2013) could help in identifying which dimensions are touched within a relation. So, for example, if there has been scenario building, definition of roles and and intellectual property regime with a partner, respectively, the anticipation, reflexivity and responsiveness dimensions have been included. However, the dimensions are not bounded by these tools, but rather open for any influence from which the dimensions can be derived.

As would be evident now, the inclusion dimension is not specifically mentioned. 'Full' inclusion cannot be detected in one relation, since it requires multiple institutions and therefore multiple relations. Only when the different institutions are sufficiently present in the system or an organisation's relations, this dimension is reached, as is expressed in the components element. For full responsibility of the system, each actor should at least be connected to sources that produce or transfer political, economic, social and human capital, to ensure a smooth diffusion of knowledge types through the system.

4.2.4. Phases of the collective innovation process

Ideally, the framework should cover the complete collective innovation process, being the complete path of an innovation from idea to implemented product under influence of the multitude of stakeholders. However, the literature has not given a proper conceptualisation of what the collective innovation process actually is composed of. It might be expected, however, that the activities for forming new ideas and exploring new technologies are inherently different from producing end products or constructing customer relations with end users. This sub section could be written in retrospect of the case study, where the data collection methods helped shed a light on different phases of the collective innovation process.

Some inspiration on what the collective innovation process might look like can come from traditional

views on innovation. First comes from Buggie (2001). In his article, four phases of innovation are defined, namely: *Strategy development, ideation, evaluation and implementation*. Other research on leadership in different phases of innovation gives three phases, namely: *Idea generation, idea realisation and diffusion*. (Waldman and Bass, 1991) However, none of these articles account for a collaborative and cooperative environment of interacting stakeholders and these phases. It seems that part of the creation of the framework should be to define which phases are present and where the framework can be applied best.

Resulting from the three data collection methods in the case study of Chapter 6, at least three different phases might be segregated, which the framework should take into account. An *exploration phase, construction phase and implementation phase* could be observed, in which the nature of the collective innovation process appeared to differ.

The **exploration phase** is used to search for new ideas, understand new technologies or policies and establish new partners. This phase was observed in a number of event visits, where actors across the established innovation system came together to discuss, promote, listen and share. A high degree of responsibility for this phase is especially important, since it ensures that each institution is included from the start of the innovation process and its objectives, values and demands are listened to.

The **construction phase** was observed in structured interviews with organisations. The organisations were either creating products, performing research projects or advocating policies and were actively partnering up with others to support these activities.

The **implementation phase** was observed in semi-structured interviews with end users. All were situations where the product was installed and the end users were questioned on their perspectives on the product, the cooperation of other actors and their inclusion, while trying to create an image of the responsibility of this final phase. Participation of end users is naturally most relevant in this phase. However, it can be argued that the exploration phase can also be initiated with end users, since the collective innovation process is a recurring phenomenon. It shows that this is by no means a confidently defined segmentation.

This segmentation of the collective innovation process is nothing more than an easy conceptualisation, that served to validate the use of the three data collection methods. It is certainly expected that the phases might be segmented further or completely other parts of the collective process might be discovered. However, as a result from the initial case study, it could be determined that a segmentation is in any form needed to differentiate among the different activities in the innovation system.

4.2.5. Enabling Conditions for Responsible Innovation Systems

With a published article in a Triple Helix journal, the researchers Cai, Pugh and Liu have done a synthesis that shows the enabling conditions for a region to develop according to the Triple Helix Systems, partly motivated from the critiques that the framework insufficiently takes into account national and regional contexts. (CAI et al., 2015) Through a careful reading of the paper by Ranga and Etzkowitz they exposed the four tangible conditions that are embedded in their text. Furthermore, with the help of a study on system failure literature, they came up with seven intangible conditions that need to be in place for a smooth development of the innovation and knowledge system. The researchers address the notion that there are many more factors that determine regional development, but have purposely decided that the ones presented are the most important. The conditions allow for policy makers to better address the issues that their regions are facing. Where currently it is only partly understood how innovation policy really accelerates the innovation process (Fagerberg et al., 2013), the conditions at hand help bridge that gap. Now, the conditions can be expanded with conditions for a region to develop according to the Responsible Innovation Systems framework. First, new conditions for the extension towards the Quadruple Helix in the components, second those that would apply to Open Innovation in the relations and lastly the conditions to systemic Responsible Innovation in the functions. In Figure 4.3 the enabling conditions as derived from Cai, Pugh and Liu are represented, with in blue the additions by this research. A small explanation on the original conditions is given.

The tangible conditions are more touchable, more easily measured. The function of the system explicitly contains the generation, diffusion and use of knowledge. Therefore it is very important that there

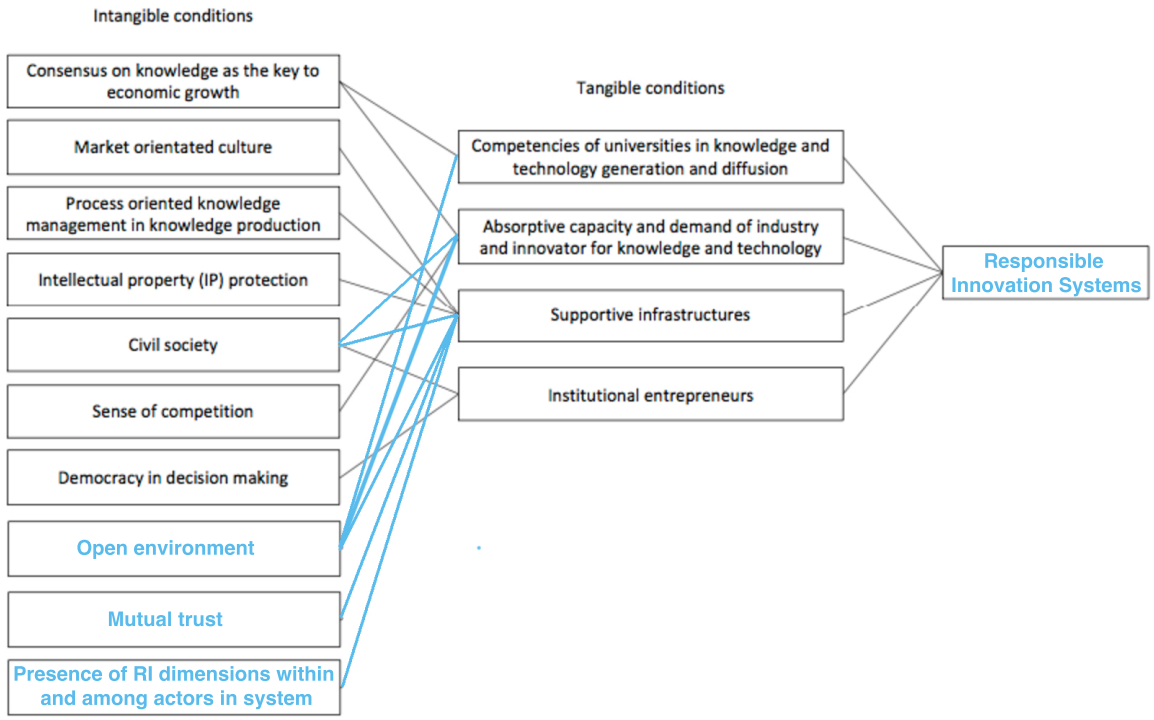


Figure 4.3: Enabling Conditions for Responsible Innovation Systems as adapted from (CAI et al., 2015)

are *competent knowledge providers*, often dominated by universities, though it might be argued that universities can be replaced by any knowledge producing entity. Furthermore, the actors in the system must want knowledge to flow into their organisations and be able to apply it. *Absorptive capacity* is defined as: A firm's ability to recognise the value of new information, assimilate it, and apply it to commercial ends. (Cohen and Levinthal, 1990) Also there needs to be a *supportive infrastructure*, like policy, fiscal or communication channels to be a catalyst for high tech start ups, university spin-offs and other quadruple helix actors to emerge. *Institutional entrepreneurs* are actors who not only start diverse changes in the institutional environment but also actively implement such changes. (Battilana et al., 2009)

The intangible conditions are more vague and harder to put in measurement. *Consensus on knowledge as the key to economic growth* is needed, where there is a broad understanding of the necessity to have new technologies and products for economic development. A *market oriented culture* has to do with institutes taking over roles of the other where the norm is self interest and profit, for example universities engaging in business activities and businesses engaging in human capital creation activities. To make certain that knowledge accumulation and learning from existing knowledge is done, a well designed *knowledge process management* is needed, creating routines through adoption of best practices and repeating of organisational processes, to allow for efficiency improvements. (Benner and Tushman, 2002) Another condition, often mentioned to be a difficult one to establish, is a coherent protection of *Intellectual Property* (IP). Subsequently, Etzkowitz implies that successful Triple (or Quadruple) Helix operation is not solely coordinated by the state, but also depends on the inputs at the local level, creating the condition of *civil society* that needs to be present. (Etzkowitz, 2008) A *sense of competition* relates to a system where strong feedback loops apply, in which the quadruple helix is most likely to develop. Think of government imposing policy to which either positive of negative feedback can be seen either making change or no change. Lastly, *democracy in decision making* is needed to be able to adopt feedback from participants in the policy making process. A political system in which social groups and individuals are involved and have a chance to influence it is needed, highly resonating with the RI dimension of inclusion.

The several additions that form the Responsible Innovation Systems framework require their own

conditions. The addition of the Quadruple Helix unfolds in the public or civil society as a institution in itself. Since the presence of civil society was already one of the conditions, the line of argument is easily drawn that there is no additional condition needed, apart from the extra drawn line from civil society to supportive infrastructures. Since civil society needs to be able to organise itself to accordingly behave as an institution, these are seen as related. Also absorptive capacity and demand for knowledge needs to be established for civil society to fully work as a contributor to innovation.

Fortunately, conditions for Open Innovation were already found in 3.2.3. Evidently, there must be an *open environment* of knowledge sharing. Organisations must be aware that there is an open environment and understand its potential value. This environment shall build the competencies for knowledge diffusion, but will also need more supportive infrastructures, such as an recognised intellectual property (IP) regime and communication structures. Actors must thoroughly examine their external contacts, ensuring that there is *mutual trust* and all risks are known, this also can be backed by an IP regime as supportive infrastructure. (Westergren and Holmström, 2008) Absorptive capacity is one of the pillars of OI, therefore the line to this tangible condition is also drawn. Furthermore, OI activities are dependent on the availability of external knowledge, making it necessary that a functioning innovation system is in place. (Wang et al., 2012) The latter is a bit the story of the chicken and the egg, but considering that the conditions are meant to enable a responsible innovation system, this can be seen as solved by the existing functions.

Finally the conditions to Responsible Innovation can be added. The dimensions of anticipation, reflexivity, inclusion and responsiveness should be present within and among actors of all institutions. This means that every actor should at least have the RI dimensions internally as well as share the RI dimensions with all the other institutions in their relations. The tools to get to these dimensions, as mentioned by Stilgoe et al. (2013) are the ones that will facilitate this and are, for the sake of simplicity, grouped under supportive infrastructures, explaining the connection.

4.2.6. Measuring the responsibility

Now that the elements of the framework are clear and the collective innovation process has been segmented, it can be more thoroughly described how the responsibility of the system is measured. The responsibility is measured as the accordance to all the elements of the framework and that is why those elements are used for the main structure in this sub section. However, the method can also differentiate within phases, creating another layer of explanation. Since responsibility is not a tangible thing, it is difficult to establish which configuration of accordance to the framework elements is 'more responsible'. Therefore, the responsibility is expressed in a description of each element separately.

Measuring the components

The components element effectively shows the inclusion of the different institutions of the Quadruple Helix. It can be determined, through the framework, if each institution is sufficiently included and whether the specific capital it creates is present in the knowledge flows through the boundaries of the researched entity.

Measuring the components in the **exploration phase** is nothing more than accounting for which institutions are present in the actors that attend the event and are able to participate in knowledge sharing. If each institution is represented and/or each type of capital is created or shared, the box of that institution will be ticked as included.

Measuring the components in the **construction phase** becomes a bit more complex. It is determined for every participant in the case study, to which institution they belong. Also each participant is asked to uncover their partners, which are also evaluated on their institutional position. An important insight is that here the presence of multi-institutional organisation becomes apparent, for each organisation can potentially encompass all institutions. It can then be determined for each institutional configuration what percentage of the system it takes. The percentage shows the relative inclusion in the active system. At the same time, however, the inclusion of each institution per individual participant is also addressed, so that clustering of an institution around a single participant does not blur the actual configuration of the system. Furthermore, apart from determining the institution of the components, some additional characteristics might be exposed here, such as whether the actors performs R&D, if

its focus is really on the researched innovation system and where it is geographically located.

Measuring the components in the **implementation phase** is also slightly different. Here the focus is on the specific capital that each institution is responsible for, so political, economic, social and human capital for respectively the institutions of government, industry, civil society and academia. For example, it can happen that human capital is being created with end users, without the presence of a university of school, but simply by the design of the project itself. In this case, the inclusion of the university component is still reached, because the function of the institution is being fulfilled. Still, actual presence of a university or school would also comply to fulfilling inclusion of that component.

Measuring the relations

The relations element, that was constructed with Open Innovation, aims to expose if there exist two-way communication and knowledge channels. Alignment of goals, targets, values, roles and resources, according to the dimensions of Responsible Innovation, can only happen if parties at both sides share knowledge about their internal views on those subjects. For the different phases of innovation it is therefore important to determine the boundary across which that knowledge flows.

Measuring the relations in the **exploration phase** is taken over the boundary of the event organisation. Outward knowledge flow is seen as the knowledge that is provided by the activities of the event and its partners. Inward knowledge flow comes from the participants of the event, so in what manner is there an interactive environment that allows participants to freely speak their minds and transfer knowledge.

Measuring the relations in the **construction phase** is done over the boundaries of organisations that participate in the case study. For each relation, or partner, the organisation has, it is determined if two-way knowledge flows exist between them, or if its rather a one-sided relation. In this phase, however, the interview with an organisation might leave room to ask additional characteristics about the relation to enrich the data, such as when the collaboration started, what the intensity of contact is, what type of relation, the type of contact

Measuring the relations in the **implementation phase** is taken over the boundary of the end user. So outward knowledge flow happens when the end user manages to transfer its information to other stakeholders. However, it may also be knowledge about the end user, rather than from it, in cases where the end users are observed on their behaviour. Inward knowledge flow comes from outside parties to the end users, for example, when end users are instructed about new use cases, products or services.

Measuring the functions

Measuring the functions of the framework will be done by finding evidence for formation of the virtual spaces. Since these spaces are virtual, the data can predominantly be measured qualitatively. The Knowledge Space consists of knowledge creation and knowledge transfer activities, the Innovation Space generally of the creation of new products and services. The Consensus Space is the embodiement of the RI dimensions of anticipation, reflexivity and responsiveness (inclusion is covered by the components). Measuring these dimensions has proven a difficult task, as the case study will show, and it can already be said that for future applications of the framework, the measurement of those dimensions needs to be revised.

Measuring the functions in the **exploration phase** is done by appointing factors that can contribute to either of the spaces. For the Knowledge Space, this means the creation of new knowledge and the transfer of it. Any activity during events that might contribute to this will help form the Knowledge Space. For the Innovation Space, this lies in the active combination of that knowledge, leading to new products, services and applications. The Consensus Space is formed when a contribution is found to each of the RI dimensions of which inclusion is already determined in the components segment. A broad intake is done, where any form of anticipation on the future, reflection of activities and roles or creation of resources that might aid in responding to changing situations can be seen as a contribution to the Consensus Space.

Measuring the functions in the **construction phase** is not that different from the exploration phase. The Knowledge Space is enhanced by R&D performing actors and knowledge transfer channels. The Innovation Space is constructed by actor and collaborations which perform activities that create new services, products and applications. The Consensus Space is constructed when actors are found to

contribute to each of the dimensions, however, they must also actively share these with their partners in order to properly align targets, roles, resources and values. A contribution to the dimensions is also measured from a broad intake, where any form of anticipation on the future, reflection of activities and roles or creation of resources that might aid in responding to changing situations. Eventually, a percentage of responsibility can be measured, taking the part of the partnerships that contribute to the Consensus Space from the total amount of partnerships found.

Measuring the functions in the **implementation phase**, again does not differ much from the others. The Knowledge Space is formed through active knowledge creation and transfer, which can also be data about end users. The Innovation Space is formed whenever end users participate in the innovation process and new products are formed with their help. The Consensus Space, again is defined with the RI dimensions, were a broad take on what it means to anticipate, reflect and respond is taken and in what manner the end users do this themselves and in combination with their relations.

Measuring the conditions to a responsible innovation system

The conditions to an innovation system have not been truly measured in this research, since each of the conditions might pose for a completely separate thesis project. However, after the case study a more descriptive explanation on each of the conditions is done with all observations made during the data collection moments. This should generate a general idea on the conditions, but it should be expected that more research will be needed to truly measure these conditions separately.

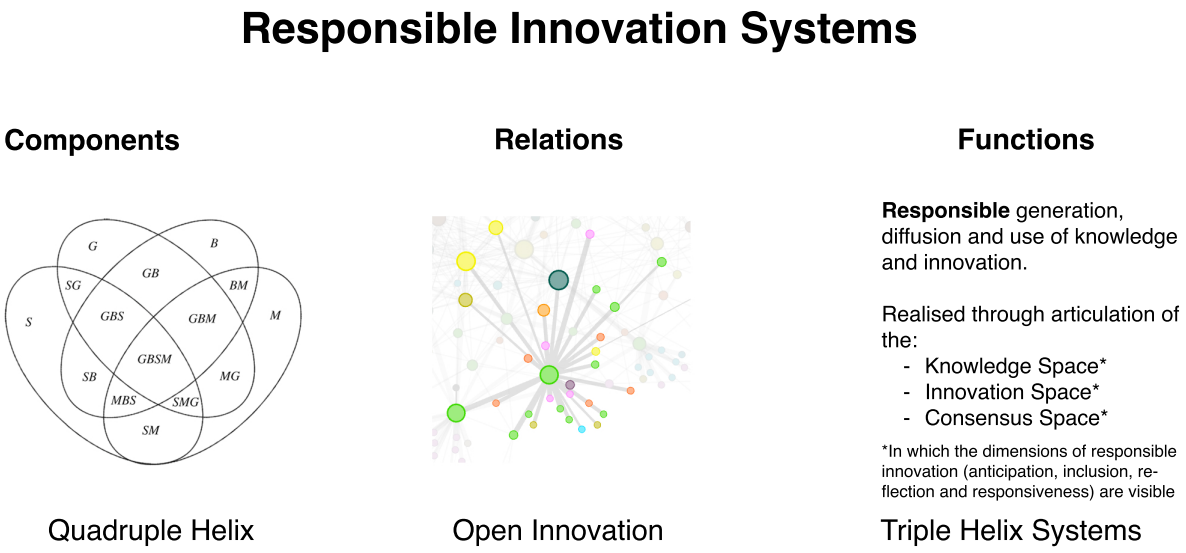


Figure 4.4: A synthetic representation of the Responsible Innovation Systems Framework

4.3. Summary of Framework

Following the innovation theories that were openly discussed in previous chapter, where also the suggestion to a combination was done, this chapter has seen to answer the question: *What framework can be constructed to expose responsible innovation practices on a systemic level?*. The chapter started with a conceptual explanation of how the separate theories of Systems of Innovation, Triple & Quadruple Helix and Open Innovation can be combined with Responsible Innovation and on what grounds this seems like a sensible thought. A sub combination of Systems of Innovation and Triple Helix, proposed by Ranga and Etzkowitz served as the main building block, with which the other theories could be merged. The combined framework allows for analysis of the building blocks of a collective innovation process, where knowledge creation, transfer and combination are central, while contributing to each

dimension of Responsible Innovation. For clarity that is later needed in the data collection, the collective innovation process is segmented in an exploration, an construction and an implementation phase.

The combined framework consists of 3 elements, namely the components, the relations and the functions. The components is where all possible institutional actors are found, guided by the actors that the Quadruple Helix ascribes. The relations element is considered with Open Innovation insights, where knowledge flows are the most important factor, requiring openness that is expressed in two-way channels of knowledge and communication between actors. Lastly the functions of the framework, under influence of RI, are: *Responsible generation, diffusion and use of knowledge and innovation, which is realised through articulation of the Knowledge, Innovation and Consensus Spaces.* Those spaces are virtual arenas where knowledge is created, knowledge is combined towards innovation and consensus over things such as targets, risks, roles, resources and values is reached.

Since the collective innovation process contains several activities in different moments, the complete process should be evaluated on different segments of that process. Literature does not provide a segmentation of the process, that is why an initial break up is proposed, separating in an exploration phase, construction phase and implementation phase. Each of those phases shall be evaluated with the framework with different data collection methods in the case study.

A number of conditions have also been set up, to which the ecosystem of the researched case must suffice before a responsible innovation system can emerge. They exist out of ten intangible and four tangible conditions. The most important additions that this research provided to the conditions is the necessity of an open environment, mutual trust and the presence of Responsible Innovation dimensions within and among the actors. The conditions are applied to get a better insight in the context of a researched case at hand.

Measuring the responsibility is defined differently for each of the phases and the conditions, looking at accordance to each of the elements of the framework. Most of these measurements are done qualitatively, because of the intangible nature of responsibility. For example, a way to conceptualise the degree of responsibility in the construction phase of the collective innovation process, is the percentage of relations that contribute to the Consensus Space, which is defined as containing activities that have anticipation, reflexivity and responsiveness. The case study shall explain in more detail what these measurement entail. Before that, however, next chapter tries to giver a better overview of the context of rural energy technology in India so that the actors that should be taken as participants in the case study can be better defined.

5

Institutional Characteristics for the Indian Rural Energy Technology Sector

What are the characteristics of institutions influencing innovation in the Indian rural energy technology sector? - Any functioning innovation system, responsible or not, is governed by its context. The right conditions must apply for innovation to happen. This chapter will dive into the four institutions that the proposed framework of Responsible Innovation Systems prescribes to take into account in relation to the Indian rural energy technology sector. The contexts of Government (5.2), Public (5.3), University (5.4) and Industry (5.5) shall be drawn, to an extend that is relevant for further consideration in answering the main research question of this thesis. While there exists a methodological approach to assess the performance of the energy sector in developing countries (Jamasb et al., 2005), this chapter rather handpicks some material to show what are the main influencers of the sector. First, however, in Section 5.1 it shall be defined what is considered as rural energy technology.

5.1. Definition of Rural Energy Technology

It should be clear what is understood by the term rural technology. In a traditional power system with large scale generation, such as coal or nuclear plants, a connection is established to a high voltage transmission level and a lower voltage distribution level that supplies electricity to customers. Because of a failing distribution segment in India, the last mile connectivity is often not in order and rural areas are therefore often deprived of a reliable source of energy. Because of this failure to supply electricity from top down, bottom up initiatives have been developed to give these rural areas access to energy nonetheless. For this research, the technologies that make this happen are considered for to be rural energy technologies. Energy technology can be divided into five scales, from small to large: (Alstone et al., 2015) (Kempener et al., 2015)

1. Charging of small household goods (mobile phones) *<5 W*
2. Solar Home Lighting (SHL) *<20W*
3. Solar Home Systems (SHS) *<100W*
4. (smart) Pico/Nano/Mini/Micro-grids *(< 1/ <5/ <100/ <100,000 kW)*
5. Central grid *>100,000 kW*

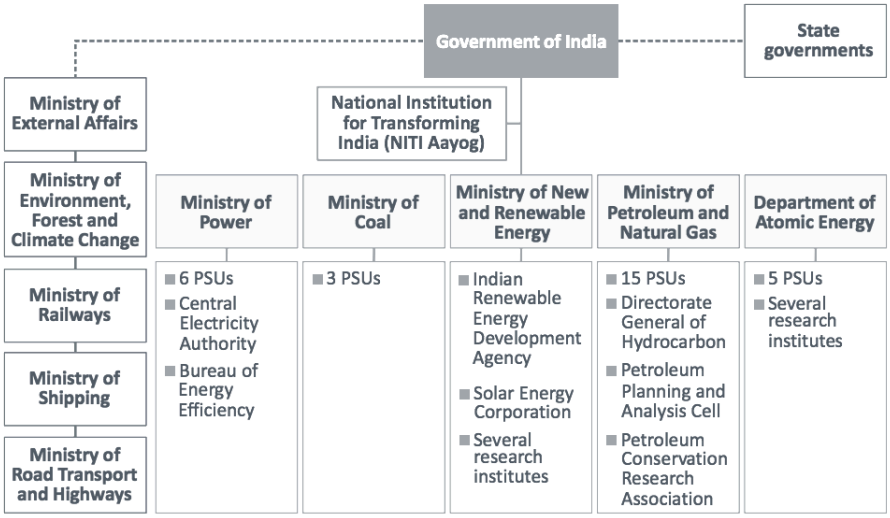
The bottom up initiatives that make up rural energy technology are composed of the first four, since they can and are being installed in off-grid situations. It is expected that with growing wealth, communities will gradually go to higher scales. While technically, diesel generators can power grids in rural areas, this research aims to have a contribution to the sustainable development goals, as explained in the

introduction. That is why there is a specific focus on renewable energy technologies and fossil fuel powered generation for the first four scales is avoided. This is backed with the argument that current costs of diesel power grids are already larger than renewable sources. (0.5€ per kWh for diesel power grids compared to 0.34€ per kWh for solar grids with batteries). The prospect is that this difference will grow further, making diesel powered grids economically unattractive and therefore unlikely to be the choice of technology in the future. (Comello et al., 2017)

At the same time, however, the extension of the central grid by the distribution companies (DISCOMs) towards rural areas is becoming more relevant, making the fifth in the list a part of energy technology that should at least be mentioned. The power coming from the central grid is mostly fossil fuel based. While one might think that central grid extension to rural areas is a good thing from a humanitarian perspective, for the rural energy sector this government induced activity is actually a large incalculable threat that is preventing the rural energy sector from thriving. (Comello et al., 2017) It shows the important role that government policy schemes have. Next section goes deeper into the role of the government.

5.2. Rural Electrification by the Government of India

In India a large amount of policy schemes exist, focused on all energy types and scales. Figure 5.1 shows the main institutions that influence energy policies. In the past 5 years, the Government of India (GoI) has positioned itself as one of the most ambitious governments in renewable energy targets, electrical vehicles goals and electrification of the rural areas. In order to fully understand some of the problems in the energy sector of India, a historical perspective is necessary, where all these schemes are addressed. Preliminary to this thesis, an internship report by the writer has seen to such a perspective, that is why the time here is taken to focus more specifically rural electrification schemes. In order to make the insights and the relevance of that policy analysis known, the specific chapter from the internship report has been added to to Appendix F.



Notes: PSU = Public sector undertaking (state-owned enterprise). Other ministries with responsibilities relevant to the energy sector include the Ministry of Urban Development, Ministry of Water Resources, Ministry of Agriculture, Ministry of Finance and the Department of Science and Technology.

Source: Adapted from (IEA, 2012).

Figure 5.1: Main agencies in India with influence on energy policy (International Energy Agency, 2015)

5.2.1. Short description of impact of past energy policies

A few insights from that section of the report from Appendix F can be summarised here, so that important government agencies are known. The decades of reform started with the Electricity Act of

2003. It aimed to unbundle and privatise the electricity sector and instituted the Central and State Electricity Regulatory Committees (CERC/SERCs), responsible for federal and state policy making in the electricity sector, which are not even visible in the Figure 5.1. While the act surely has had some positive influences, many of the operational problems that are present in the rural energy sector have been created in this specific policy. While privatisation was the right move, it was done before the electricity sector was financially sound, creating the opposite of the intended effect. (Kessides, 2012) Now the still largely loss-making DISCOMs are failing to connect the majority of the population and high operational losses throughout the sector are still not being accordingly solved. Electricity tariffs by public distributors are very low, below the cost price of electricity even, due to subsidising by the government to spawn development through cheap energy. In Gujarat, for example. the tariff from the central grid is INR 3.74 per kWh (0.05€ per kWh). Unfortunately, the privatisation came before tariffs were brought back to normal levels, because of public opposition. Essentially, every transfer of energy of public DISCOMs is draining the government budgets in a vicious cycle that is not easily broken, but unsustainable in the long term. Privately owned microgrids in remote areas operate with the higher tariffs, that better reflect the costs of electricity. However they are facing the threat of central grid extension to their areas, that is happening under influence of the Deen Dayal Upadhyay Gram Jyoti Yojana (DDUGJY) scheme, which will be explained later. Because the communities will switch to the cheaper form of electricity and there is no scheme in place to protect the investments of the microgrid operator, the risk of such projects has led private investors to avoid the rural energy sector and rural electrification numbers to be behind on schedule. (Comello et al., 2017) Fortunately, a number of recent schemes is trying to solve this barrier to rural electrification.

5.2.2. Recent Policy and regulations focused on rural electrification

Several policy schemes can be mentioned that are influencing the rural energy sector today on both the federal as the state level.

Ministry of New and Renewable Energy (MNRE) - draft national policy on renewable energy based mini/micro grids

In June 2016, the MNRE released a draft proposal aiming for penetration of electricity in rural areas. (MNRE, 2016) In the proposal the MNRE seeks to resolve the problems in the electricity distribution segment, sometimes called the last mile connectivity. It defines important roles for The State Nodal Agency (SNA) as governmental entity, the Village Energy Committee (VEC) as a community organisation and the Energy Service Company (ESCO) as the industrial party. They are responsible for, respectively, governmental control, uniting the villagers in the decision processes and installation, operation and exploitation of the envisioned rural energy technologies in the remote areas of India. SNAs is a more general term for other policy sectors as well, but in the case of rural electrification the role of SNA is often given to state (Renewable) Energy Development Agencies (REDAs), with the objectives to promote, expand, develop, coordinate and finance the growth of efficient energy use of renewable energy in their respective states with research projects. Therefore the SNA is particularly suited for the role of government agency in the open innovation collaboration strategy model of Section 3.2.3. The SNA should therefore govern a process where the ESCO and the VEC are included to maintain a responsible innovation process, as long as it takes the role of university or a university is added to the collaboration in order to create human capital.

The MNRE policy allows for any private party to enter the market freely and operate a microgrid according to a self-specified tariff. Only when state-level subsidies are granted, the SERC or SNA shall set the tariffs. At the same time the policy acknowledges the parallel existence of microgrids and the central grid and offers an three options for microgrid operators at the time of interconnection with the central grid. Firstly, the two parties can enter into a Purchase Power Agreement (PPA), where energy is exchanged at the boundary of the two systems. Secondly, the microgrid operator can charge a fee for the DISCOM to make use of its infrastructure. Lastly, the microgrid operator can decide to sell all its assets to the DISCOM, under a SERC decided framework, and transferring all its operations to it, therefore providing a full exit possibility.

Uttar Pradesh Electricity Regulatory Committee (UPERC) - Mini grid policy

The first state to issue a coherent mini-grid policy was Uttar Pradesh (UP). (UPERC, 2016) Every state that has brought out drafts on mini-grids has largely copied the UP policy. In it, mini-grids were not

considered stand-alone operations anymore, but could potentially integrate with the existing grid. The policy offers two options between which entrepreneurs can choose. The first is a collaboration with the UP government, that assigns the villages to receive a mini-grid and sets the technical standards and tariffs while the entrepreneur gets a 30% subsidy in return. The other option is to operate without restriction, but also without subsidy.

For interconnection with the central grid, the mini-grid operator has different options, depending on whether the central grid was already present at instalment. If not, the policy follows previous MNRE policy, with an additional fourth option to transfer all distribution assets, but keep the generation assets. If the grid was already present, the options remain similar apart of the option of selling electricity generated at the state-mandated fee, which only becomes available after a three year waiting period.

The policy is putting extra attention in honest activities by the DISCOMs, since they need to be able to compensate for the distribution assets and offer a PPA to mini-grid operators. If DISCOMs do not follow the regulations, they risk a fine from the state.

Ministry of Power - DDUGJY

In order to provide a continuous power supply the remote and rural areas. The DDUGJY scheme contains funds of 10.7 billion euros, to reach the following objectives (Ministry of Power, 2015):

- To provide electrification to all villages
- Feeder separation to ensure sufficient power to farmers and regular supply to other consumers
- Improvement of sub-transmission and distribution network to improve the quality and reliability of the supply
- Metering to reduce the losses

Looking at these objectives, it might be considered strange that some costs are not accounted for in the scheme, such as advanced meting infrastructure, prepaid or smart meters, service lines to consumers, under-ground cable work, salaries of the workforce or not even distribution automation and IT applications. It leaves to question what this money would actually be spend on to ensure a sustainable electricity network.

The DDUGJY rural electrification scheme of the MoP has sanctioned 5236 projects to electrify 128,432 un-electrified villages, intensive electrification of 655,247 partially electrified villages and provide free electricity connections to 420,040,000 rural households. It is important to know that the definition of an electrified village is as follows:

- Basic infrastructure such as distribution transformers and distribution lines are provided in the inhabited locality as well as the Dalit Basti hamlet where it exists.
- Electricity is provided to public places like schools, panchayat office, health centers, dispensaries, community centers etc.
- The number of households electrified should be at least 10% of the total number of households in the village

The nodal agency in charge of this is the Rural Electrification Corporation (REC). The REC provides loans to SERCs, rural electric cooperatives, central and state power utilities, private power developers and NGOs. Part of the activities that the REC does is active monitoring of the set targets, which is publicly available through the garv dashboard. (Rural Electrification Corporation, 2017) It shows the progress that the GoI is making in electrifying the Indian public.

5.3. The Indian Rural Population

Similarly to the policy chapter, the preliminary internship report also contains an extensive demographic analysis. (Hunink, 2016) Therefore this section will limit itself to the numbers that are directly relevant for the case of energy in rural areas.

The World Bank finds that in the past twenty years, the share of the population living in rural areas in India has gone down from 74% to 67%. However, the absolute number is still rising, amounting up to more than 880 million people in 2015, even though growth is slowing down to 0.6% per year. Of these 880 million, 70% has access to electricity, leaving 264 million deprived of it and being subject to energy poverty. (World Bank, 2015a) The more recent World Energy Outlook puts the number on 244 million. (International Energy Agency, 2016b) The average Indian energy use per capita is three times less then the global average, even less then that of Africa. Figure 5.2 gives a good representation of the large gap that exists. One can only imagine what will be the consequences for the world of this gap is going to be breached with fossil fuels.

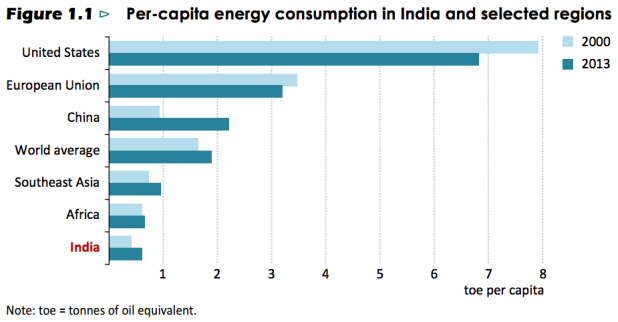


Figure 5.2: Gobal per capita energy use (in toe). (International Energy Agency, 2015)

Energy poverty means a lack of access to modern energy services. (Bhide and Monroy, 2011) This means that these people have limited options to a clean pumped water system, refrigerated food, many forms of health care and modern communication technologies. They rely mostly on traditional fuels, such as firewood, subsidised kerosene and cow dung, creating all kinds of health issues on their own. With the help of data from the National Family Health Survey in 2016, the map in Figure 5.3 has been constructed, showing the energy access in percentage of households per state.

There are three key factors at play with energy access, namely affordability, availability and household characteristics, like education levels, awareness and income. Most policy schemes only focus on affordability and not so much on the others, leaving room for improvements, according to the Council on Energy, Environment & Water (CEEW). (CEEW, 2015) A number of key findings from their report can be noted.

- Households have the largest priority of electrifying, before street lights, industries and community buildings.
- There is a huge preference of people to opt for micro- and mini-grids instead of connecting to the government grid.
- People overwhelmingly believe government should oversee energy management, but the level of wanted involvement differs across states
- People are largely willing to switch to solar lanterns at the exchange of the kerosene subsidies

While the governmental target for rural electrification was due this last May 2017, the governmental data tells that on June 11th a number of 3863 villages still needed to be electrified out of 128,432, according to the garv dashboard maintained by the REC. (Rural Electrification Corporation, 2017) However, other sources outside of government mention that only 60% of the target has really been met, due to false numbers. IndiaSpend reports that out of the 10,072 villages that were added to the electrified list, 92% do not have electricity. (Newsbytes Desk, 2017) When senior officials of the REC were presented with the miscalculations, they said: *"We put a lot of emphasis on photos. If there is a pole and*

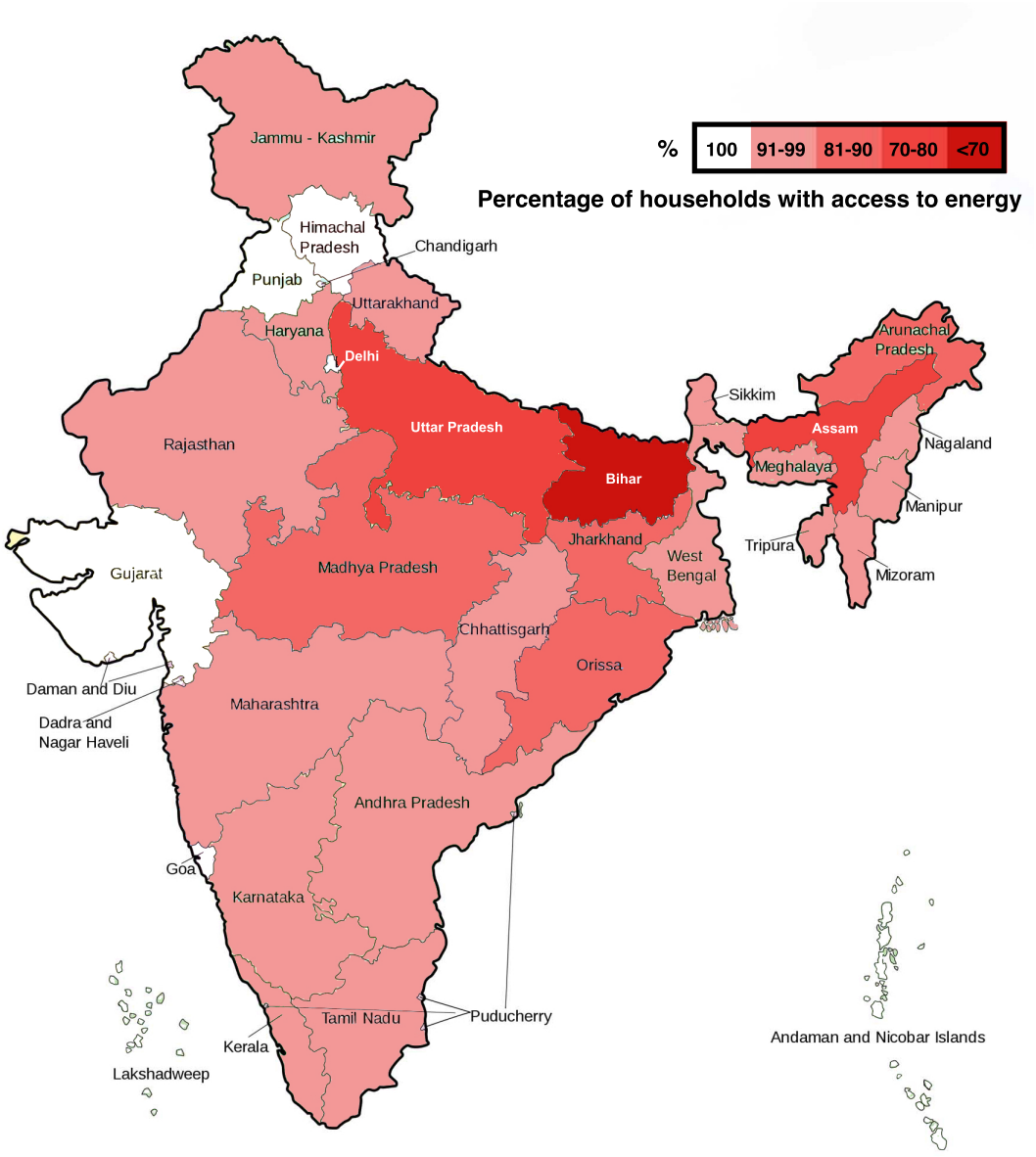


Figure 5.3: Percentage of households with access to energy per state. (Ministry of Health and Family Welfare, 2016)

distribution line visible in the photos, we call it electrified." There is a clear evidence that somewhere along the 'supply chain' from village to top-level government a corruption of data has taken place. It could suggest that the distance of the government from the public is too far for reliable data to be collected. If there is no strong local normative control, these kinds of facades can be created. The reasons for the long distance can be slow communication channels and lack of human capital on the ground. There is a clear need for skilled people on the ground, that can build and sustain the next responsible energy network of tomorrow.

Civil society is also represented in Non-Governmental Organisations (NGO) that take on mission such as poverty reduction, human rights, energy access and many more. India knows a strong regulatory framework that allows multiple different types of NGOs to be registered. This has led to a stunning total of 3.1 million NGOs that are active within the Indian borders, according to the Central Bureau of Investigation. This is twice the number of schools in the country, meaning there is 1 NGO for every 400 people. (The Indian Express, 2015) The MNRE has created a list of acknowledged non-profits that work in the rural energy access programmes of the government, which amounts to a total of 61 organisations. (MNRE, nd)

The VEC, as explained earlier in the MNRE policy, appears not to be registered, since no overview of active VECs in communities could be found. However, the civil society sphere seems to be increasingly represented by an intermediary in the form of social enterprises, that operate as ESCO-like organisations. However, more on ESCOs in a later stage.

5.4. The Indian Education System

In 1955 the Nobel Laureate in Economics Milton Friedman called the potential of India's scientific and technology knowledge as great as that of The United States a century before. India is home to some of the oldest ancient universities, where 2700 years ago the university of Takshashila already attracted thousands of students from all over the world. Still, the Indian education system is considered the 3rd largest in the world. Also their higher education system is performing well and offers education and training in nearly all aspects of human creative and intellectual activities, with an emphasis of science and technology. (World Bank, 2006)

Therefore, the base for an immense spur in human capital creation has been lain years ago already. The national enrolment of young children in primary schools between the ages 6 and 14 is 96.7%. This shows the potential upcoming quantity of human capital in the country. In the education system, private schooling is a noteworthy segment, because in 2014 more than 30% of enrolled scholars were attending a private school. (ASER Centre, 2014) Indians value education highly, sometimes putting a lot of pressure on students to perform. During the time of this research there was a common commercial visible on the Internet that tried to spread awareness about the negative side-effects this pressure has on the student. The age group of 15-29 is the largest contributor to suicides in India, supposedly because of an increased pressure to perform. (Patel et al., 2012) Many of the best performing students are striving for more and are moving abroad to study at high level international institutes.

India is a traditional country and traditionally the role of creating human capital has been appointed to universities, even though in the knowledge democracy these roles will be changing. The TU Delft is such a university that acknowledged the need for entrepreneurship and inclusion in order for responsible innovation to be possible. It is therefore that the contribution of the TU Delft in the form of this thesis was possible. It should be expected that social, political and technical science is present in a responsible university sphere and, for the case study of this research, all related to rural energy. But are these universities or research centres to be found in the system, that can influence development in rural energy technology? Where are the people being trained that will work in the rural energy sector?

The total number of universities in India is found to be 789, which are well-spread across the country with each state having at least several, as determined by the University Grants Commission. (Ministry of Education, 2017) They are divided in central, state, private and 'deemed-to-be' universities. The latter are higher education institutions that specialise in a certain topic and have done this with such high standards that they were granted the status of university. A notable deemed-to-be university is The Energy and Resources Institute (TERI) University, based in Delhi, which aims to be the most advanced research institute for sustainable development. It is the educational branch of the TERI research institute, which is found one of the most active players in the rural energy system in terms of research projects on social, political and technical elements of the sector.

For the technical part of the needed human capital, there are also institutions that are not officially flagged as universities, but have an important human capital contribution. Indian Institutes of Technology (IIT) and National Institutes of Technology (NIT) fall under this segmentation. In Figure 5.4 a map is drawn where all these institutions can be seen throughout the country. It shows that in the regions where rural energy technology is needed most, at least technical institutes are present that can perform research in the area. Additionally there are a number of societies and private schools that focus on engineering, a total of 4398 are approved by the All India Council for Technical Education. (ITA, 2015)

For the social sciences addition to the system, an important institution governs a number of organisations, namely the Indian Council of Social Sciences (ICSSR). The ICSSR has a network of 29 research institutes, that all share the objectives of promoting social sciences among the Indian public and creating human capital in this area, also often touching political subjects. Similarly, for political science

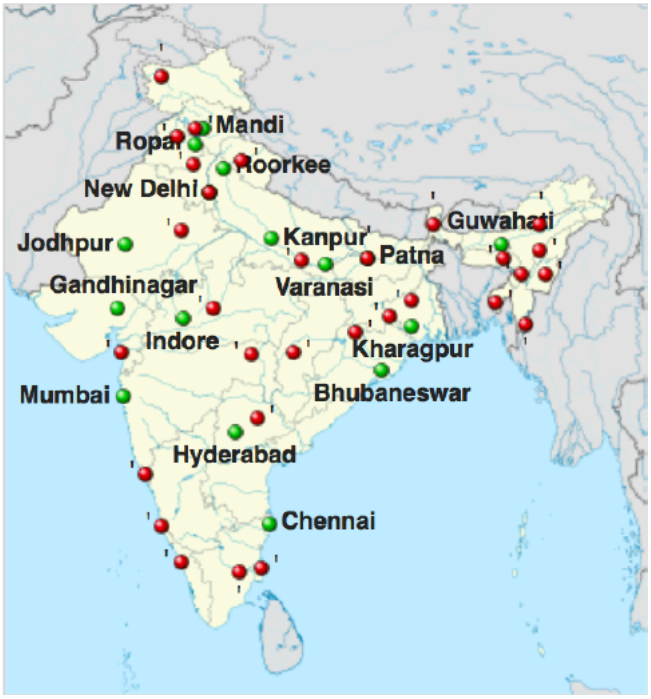


Figure 5.4: Overview of IIT (green) and NIT (red) locations throughout India (Dedering, 2017)

there is the India Political Science Association (IPSA), founded in 1938. It is the largest collective body, connecting more then 3000 professors, teacher scholars and researchers in the political science sector throughout all of India.

It seems that the educational foundations for a well working innovation system are definitely in place. Numerous research and educational institutes exist and the importance of education and knowledge is clear among its population. However, from Section 3.2.3 it was seen that in Indian university-industry collaborations, there was a negligible increased performance effect for industry partners, while foreign university collaborations did spawn better performance. (Kafouros and Forsans, 2012) While the human capital creation sphere looks healthy and productive on its own, because of a lack of incentive for industry to connect to university there can be raised questions about the ability of the universities to diffuse their knowledge throughout society. The responsibility of the entire innovation system might be undermined if universities cannot connect properly to the other institutions, such as that of industry.

5.5. Indian Rural Energy Industry

After privatisation of the energy sector, industry has started to be an institution of relevance. Initially the introduction of private parties into the sector was slow, but due to pressing measures, in recent years the acceleration is increasing. In 2014 the share was almost 40% of private generation. Figure 5.5 shows this increase. Developments in the technology have accelerated immensely in the last years and the acceleration has just begun. The smart grid market in India is said to rise from 14 million to 7 billion euros (100 to 50,000 crore of rupees) in the upcoming five years, because of GoI plans to create 100 smart cities and 500 smart villages, creating numerous projects for private partners. (India Times, 2016) The city of New Delhi, India's capital, has also announced a plan to spend 7 million euros on a smart grid project, which makes it an interesting region to keep an eye on regarding smart grid developments. (Metering Smart Energy, 2015) However, for rural areas those projects seem not to apply.

Figure 5.5: Change of energy generation after privatisation. (International Energy Agency, 2015)

Still, in the MNRE policy there is an important role for the Energy Service Company (ESCO) as a private entity, that is responsible for the economic exploitation, operation and maintenance of rural energy projects. The shape this ESCO is likely to take is that of a SME, operating in local contexts. The challenges, however, that still lie in electrifying the rural areas in a sustainable way, require a great deal of innovation and entrepreneurship from the ESCO.

One of such ESCOs, for example, is Rural Spark. It is a social enterprise aiming to electrify the bottom of the pyramid with solutions adapted for local contexts. In the case of Rural Spark, it is solar home systems they provide, while others create microgrids or smart meters. Since innovation in new product appears to come mostly from these kinds of actors, they pose an interesting participant for this research.

Schumpeter already observed in 1934 that entrepreneurship is a driver of innovation. (Schumpeter, 1934) Through the formation of novel companies, new knowledge is created, exploited and transferred between actors that are working together on societal problems. (Braunerhjelm, 2011) In developing countries the central position of SMEs is especially important, providing the linkage between end users, multinationals and universities. (Szogs et al., 2009) That is why the concept of entrepreneurship in the ESCO is important to consider in the clarification of responsible innovation.

The characteristics of entrepreneurship that influence the processes of technological development need to be determined. Often, the entry of new companies in a market is used as a determinant for economic growth. (Van Stel et al., 2005) The impact of new firms has also been shown in developing countries through, for example, job creation. (Ayyagari et al., 2011) However, Vivarelli shows trough an extensive literature study, including a perspective towards developing countries, that so called entry mistakes exist.In other words new firms that have a higher chance of failing are present. (Vivarelli, 2013) This is particularly interesting to be able to determine up front, whenever a potential partnership is considered. Therefore, when looking at entrepreneurs entering the market, Vivarelli exposes the need of distinguishing 'opportunity', 'necessity' and 'revolving-door' entrepreneurs.

Opportunity entrepreneurs are the ones that make true innovation happen, and should therefore be the focus for potential partnerships. They spawn from progressive reasons for market entry, such as expected profits, expected growth and high innovative potential. (Acs and Audretsch, 1989) (Geroski, 1995)

There are, however, also regressive reason to enter a market, such as low salary perspective or fear of unemployment and only when these factors are eliminated, the positive relation between growth and firm entry is maintained. (Carree et al., 2007) A necessity entrepreneur is clearly not in the game to innovate, but merely to survive. Especially in developing countries many people are running their own business, selling goods or services, because they have no other option. It must be asked whether necessity entrepreneurs can be expected in the companies that surround the development of smart microgrids. Since the restructuring of the electricity sector from predominantly public to private may have forced former employees of public DISCOMs to generate new forms of income and set up a business in the sector they are familiar with. Therefore this characteristic should be considered.

Another perspective is the revolving-door entrepreneur, which is somewhat harder to examine. It can be determined by looking at the individual characteristics of the entrepreneur, instead of external influences. These individual characteristics can greatly influence the path of the company. (Knight, 1921) Examples are whether someone was formerly active in the sector, has an entrepreneurial family background or experienced a sudden personal financial capital increase. Also psychological influences such as desire for independence, autonomy, desire to be socially useful or social status are potential motivations that entrepreneurs can have to enter the market. Firms are therefore not only founded on progressive or regressive reasons, but also personal subjective factors play a role. It must be noted that, for example, having a father as an entrepreneur is not always a bad thing, on the contrary, it can have many benefits. Yet Parker explicates the psychological literature that shows empirical data on the claim that entrepreneurs are often unrealistically overoptimistic. (Parker, 2006) This overoptimism leads to a higher degree of firms that take a shot, but quickly exit the market again, explaining the term revolving-door entrepreneur. Apart from these factors that play a role at the personal level of an entrepreneur, still, market failures are particularly present at a higher dimension. Lack of access to credit, insufficient infrastructures, policy barriers and high corruption hinder firm performances in developing countries and should be considered.. (Aterido et al., 2009)

These findings clearly indicate that the 'ex ante' or 'before the event' characteristics of firms are determinants for their further development from the point they enter in the market. Vivarelli divides the most important ones in firms' size and age, credit rationing, education and human capital, previous job, innovation, escape from unemployment and the role of ethnic minorities. (Vivarelli, 2013)

Since most of the participants of the case study of this research operate partly in the industry sphere, it is important to contextualise this segment accordingly. It is therefore, that the ex ante characteristics determined by Vivarelli will be used as a part of the questionnaire. While it might not directly pose an answer to the main research question of this thesis, it will help to provide a better content of analysis for the participants themselves, therefore increasing the chances of their willingness to participate.

5.6. Summary on Institutional Characteristics

This chapter has seen to a definition of rural energy technology and a description of what the contexts of the institutional spheres as defined by the quadruple helix contribute to this.

Because of the failing top-down electricity distribution segment, the larger share of rural energy technology products are bottom up solutions. Charging of small household goods (<5W), Solar Home Lightning (<20W), Solar Home Systems (<100W) and various scales of stand-alone grids (1-100,000W) are technologies considered to fall under the umbrella term of rural energy technology, while a connection to central grids should not be discarded immediately.

Government has proven to be a complex set of policies and actors that appear to be operating from a high distance of especially the population. Through privatisation, the GoI created the inclusion of the industry, which has been the initiation for a more responsible energy sector. Arguably, the privatisation has been done too soon, however, creating all kinds of new problems. In their rural electrification the GoI has set immensely high targets, showing their ambition. However, it seems that it has bitten of more then it can chew, since false data was represented by the REC on electrification numbers. Because of the large distance, chances of data corruption increase, where photo's of 'electrified' villages are the main source of monitoring. Furthermore, the rural electrification scheme does not include several key elements of what a sustainable and modern electric grid should look like, questioning where the money is going. It appears at the same time that the government experiences low amounts of trust in some rural areas. A more local focus is needed. Still, the latest MNRE and mini-grid policies show a sign of willingness to mitigate those problems, creating an inclusive framework with the SNA, ESCO and VEC as entities representing multiple institutions.

The rural population of India is one of the biggest in the world and not easily summarised. However, it is found that the most energy deprived communities are in the states of Uttar Pradesh and Bihar. Most states want a clear defined role for the government, however some want far less government inclusion. It has proven difficult to obtain reliable data from these parts of the country, because government does not provide the reliable data itself. Still, CEEW find that the population is willing to explore new energy technologies and trade the kerosene lamps in for electric bulb, if possible. A substantial amount of NGOs exist in India, about 1 for every 400 people. A total of 61 NGOs has been listed by the MNRE as officially working on rural energy access programmes. Also the civil society sphere seems to be increasingly represented by an intermediary in the form of social enterprises, that operate as ESCO-like organisations.

The university sphere seems of sufficient body and operating in a healthy manner, which can be ascribed to the high priority that Indians have for education. There are many universities throughout the country, compassing all possible disciplines. Also on the higher level, the universities seem well connected, with several institutions governing separate segments of the academic environment. Also a number of highly specialised research and education institutes exist, such as The Energy and Resource Institute (TERI), which focuses on rural development with energy as a mean theme. However, it is important to note that there has been found evidence of negligible performance increase of firms, whenever they put time and money in cooperating with universities. This does not give an incentive to work together with Indian universities, potentially creating a problem when a responsible innovation

system is required.

The industry sector in rural context revolves around the ESCO, being the one exploiting, operating and maintaining the rural projects. They operate as SMEs and are required to do a great deal of entrepreneurship and innovation. It is therefore that the concept of entrepreneurship is more thoroughly described, where relevant characteristics are described that might be relevant to take into account as a context. With the help of Vivarelli's ex-ante characteristics, more context can be applied when the participants that operate as ESCOs are being questioned.

6

Case Study Method

In what way can an initial case study with the framework show responsible innovation characteristics in the rural energy technology sector of India?

With the help of the constructed Responsible Innovation Systems framework, an initial case study can be performed, that can bring some information on the applicability of the framework, as well as a first impression on the responsibility of the Indian rural energy technology innovation system. In what manner can the inclusion of the different institutions in the system be observed? Are there are two-way communication and knowledge channels? How are the functional spaces of Knowledge, Innovation and Consensus formed, with in the latter the dimensions of anticipation, reflexivity, responsiveness? All these question should be answered for the different phases of the collective innovation process.

Case studies are considered suitable to expose regional knowledge transfer, according to Fromhold and Werker, who used this methodology to determine the role of universities in innovation systems, as well guided by Triple Helix theory. (Fromhold-Eisebith and Werker, 2013) A case study is used here as well, in assessing and guiding the responsibility. However, Fromhold and Werker also address certain limitations to case studies that need to be taken into account.

Individual case studies might not be able to differentiate between case-specific or generic characteristics. However, using the same research design for multiple cases reduces the chance to such a failure. In such a multi-case example there should be enough overlap among cases, but also enough differences to make the comparative analysis useful. However, just a small number of examples can normally be covered, making it virtually impossible to address the complete innovation system node for node. The sample of participants that are interviewed should therefore be representative for the larger whole to make the findings valid enough for consideration.

The upcoming three chapters are answering the above-mentioned sub question, to see what kind of case study can generate valid empirical evidence to answer the main research question. Chapter 7 shows the results that derive from the case and discusses the results. This Chapter 6 explains the setup of the case study, with in Section 6.1 the way it was approached, in Section 6.2 the structure of the questionnaires for the implementation and construction phase and in Section 6.3 an explanation on the events that were visited.

6.1. Approach

The responsibility of en entire system can, presumably, only be measured by the sum of its interdependent parts. Central to the framework are the actors, the relations between them and how this contributes to the functions of the system. A collective innovation process cannot be easily analysed by inputs and outputs, because they are interdependent in between phases of the process. Its results may be small, cumulative and only noticeable over time. (Thibert, 2016) It, therefore, requires a qualitative approach to analyse a collective innovation process.

Section 4.2.4 has discussed a way to segment the collective innovation process in several phases, namely the exploration, construction and implementation phases. In figure 6.1 the segmentation of the

process is visualised, though schematically since it was also mentioned that these phases are only an initial proposal to segment the collective innovation process and other segmentation may be done. Each phase has its own activities and needs to be addressed in different ways in order to assess the complete innovation process on responsibility. Subsequently, the case study includes event visits to address the responsibility in the exploration stage, structured interviews in Questionnaire X with organisations to determine responsibility in the construction stage and semi-structured interviews in Questionnaire Y with end users for determining responsibility in the implementation phase. The responsibility of each stage is determined with the use of the framework, assessing the components, relations and functions of the system.

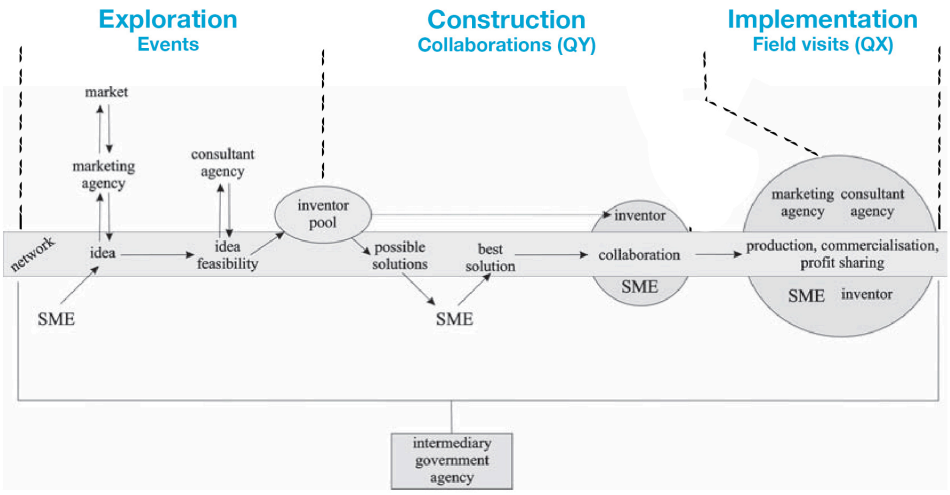


Figure 6.1: Phases of the collective innovation process in an Open Innovation framework, as adapted from Vrgovic et al. (2012)

6.1.1. Target Group

When one thinks about rural development, one thinks about a bottom up approach to raising the poor out of poverty. A decision was made to start by questioning organisations that directly put energy technology products in the hands of rural people. This target group will represent organisations in the construction phase, while customers from those organisations will represent participants in the implementation phase. From Chapter 5 is taken that rural energy products consist of small appliances, Solar Home Lighting (SHL), Solar Home Systems (SHS), smart meters and various scales of (smart) grids. Starting from companies that deliver these products to rural customers would reveal the innovation system in a bottom up way, finding the most direct connections to the end users. These are essentially the ESCOs as defined by the MNRE policy. It happens that the organisations that fulfil this activity are mainly social enterprises. If one takes a look again at Figure 3.6, it might be noted that the approach spawns from the intersection of the Industry and Public spheres (IP), as defined by the Quadruple Helix. From there on, a second iteration of participant recruitment can be done by handpicking some revealed relations of the ESCOs that fulfil an interesting role in the system, such as intermediaries. Furthermore, every participant is asked if they would be interested to facilitate an interview with their end users in the field as well, taking a further leap to the public sphere.

Several channels are tried to get an initial connection with ESCOs. First there was an attempt to meet relevant players at the public hearing of the microgrid policy in the state of Bihar, organised by the Bihar Electricity Regulatory Committee (BERC). A Rural Spark employee (Shahzeb Yamin) that was present would arrange contacts with the present stakeholders of the microgrid innovation system of the state. Unfortunately, during the meeting there was only one other party present in the form of a delegate of DESI Power, who eventually did agree to participate.

Separately an Internet search was performed, with the terms 'smart grids', 'microgrids', 'solar home systems', 'solar lighting systems' and 'smart meters' in combination with 'rural' or 'India' and relevant companies were directly approached. In addition, a meeting with Atul Mudaliar from Shakti Foundation, a renounced local research institute, was used to exchange several contacts of CEOs of ESCOs, providing a more direct link to companies. Further in the process, interviewed companies also provided contacts of their relations that were relevant.

Furtermore, a number of events were visited, namely 'India Smart Grid Week', 'ICEGOV', 'WWF Climate Solver Workshop' and a public hearing on renewable energy policy by the Central Electricity Regulatory Committee. Originally this was with the intention to recruit more participants, especially from the government and academic institutions. Unfortunately, this proved difficult, because the focus of delegates was not to make contacts with students who ask time instead of provide business opportunities. Ultimately the experiences from the event visits did provide some valuable insights that are further elaborated on in Section 7.1.

While approaching possible participants, one should always keep in mind the value system of the targeted group, especially since in this case the values might diverge from the researcher due to different ethnical background. A socialtechnical value map was created for smart grid technologies in Bihar in preparation of this project and can be found in Section B in the Appendix. Important lessons were discovered, especially issues regarding trust and empathy that could be encountered. The assignment exposed the need of initiating the contact on the basis of the potentially mutually beneficial results, derived from the value of putting a group's needs before the individual's. Every contact was thus persuaded by emphasising the benefits that this research could have to the entire ecosystem of rural energy technology stakeholders.

6.1.2. Participants

A total of thirteen companies, all social enterprises, were found willing to participate in the research. Of them, five allowed a visit to their field projects to talk with end user of their products. In the second iteration of approaching participants, four intermediary organisations were found willing to contribute, bringing the total to 22 interviews. Table 6.1 shows all organisations that are interviewed, with what products or services they are providing. The bold and underlined names signify that of these companies also a project was visited in the rural areas. Figure 6.2 shows the geographical distribution of the researched organisations, the regions they are active in and the location of the field visits in the rural areas. The two oldest organisations known in the rural energy technology sector were included in the research, being DESI and SELCO, both active for more then 20 years. It can further be noticed that the majority of activities are concentrated in the states of Bihar and Uttar Pradesh. As was seen in Chapter 5, these states are also the ones with the most energy poverty. The decision of performing the field visits in these states was based on mainly those observations.

Since companies or intermediaries and rural end users are evidently very different from each other, two different questionnaires were designed, of which one is only partially relevant for the intermediaries. Next sub section gives an overview of the structures of these questionnaires.

Table 6.1: Participants with name, type of organisation and number of states they are active in

Name	Type	# States	Name	Type	# States
Claro	***Solar Irrigation***	**14**	SELCO	*SHS / SHL*	14
DESI	*Grids*	6	**Simpa**	***SHS***	**1**
Gram Oorja	*Grids / Irrigation*	7	**Vayam**	***Grids/SHL/Irrigation***	**16**
Gram Power	***Grids/Smart Meters***	**3**	Mrida	*Grids*	5
Mera Goa Power	*Grids*	1	CLEAN	*Knowledge Network*	*N/A*
Mlinda	*Grids*	2	J-Pal	*Policy Research*	*N/A*
ONergy	*SHS / SHL*	3	Shakti	*Energy Research*	*N/A*
Piconergy	*SHL*	2	TERI	*Energy Research*	*N/A*
Rural Spark	***SHS***	**2**	-	-	-

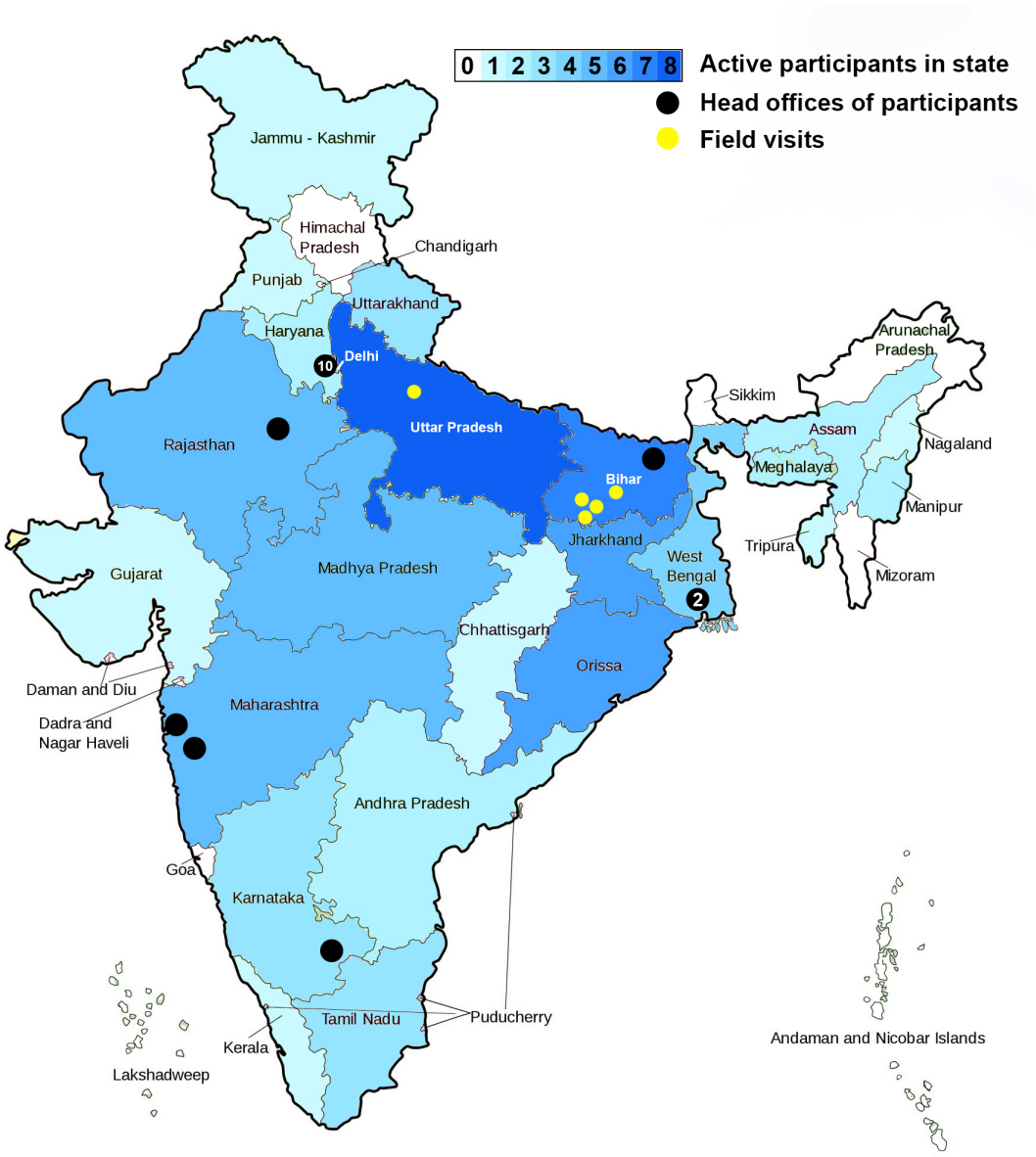


Figure 6.2: Geographical distribution of participants and field visits

6.2. Structure of the Questionnaires

The questionnaires for both the field visits of the implementation phase and the organisations of the construction phase have the aim to reveal responsible innovation practices, however they are very different in their nature. The organisation questionnaire benefits of a very structural approach to the questions, to ensure validity in the comparison of answers later on. The end user questionnaire, however, is designed more to be a conversation within communities, instead of a list of questions. This section explains the design choices that were made, while referring to Section C in the appendix, where the complete questionnaires are presented.

6.2.1. Field visits Questionnaire X

The field visits to rural communities are the embodiment of the research on the implementation phase. When questioning rural communities, it is very important to take into account that, from the villagers perspective, participating in an interview is an experience that might be unfamiliar or uncomfortable. It can be easily considered rude to come in with a list of questions and leave straight after the required information was retrieved. Such behaviour can result into villagers remaining closed and withholding

valuable information. Furthermore, it is uncertain how villagers will react to certain subjects, especially relating to the company that delivers the products and has an employee listening that came along with the interview. Topics like government can also be controversial, as will be seen in some of the findings in next chapter. Because of this, the conversation should be build up slowly and a certain level of trust should be maintained to be able to retrieve the needed answers. This leads to a diverging structure for different cases of those community conversations, reacting to the contextual environment and staying open minded for new influences or questions that can be asked. In the literature, this technique is conceptualised in the term 'semi-structured interviews'. (Longhurst, 2003)

Semi-structured interviews have some degree of predetermined order, but remain with a layer of flexibility. The questions that guided the conversations can be found in Section C.1 in the Appendix, under the label of Questionnaire X. These questions are asked to a variety of end users in the form of shop owners, households, village communities, farmers and village level entrepreneurs from projects of Simpa, Gram Power, Vayam, Rural Spark and Claro in the states of Uttar Pradesh and Bihar.

An important factor during the interviews was the presence of Shahzeb Yamin as an interpreter. Shahzeb is a field expert, working with Rural Spark and originating from the Uttar Pradesh and Bihar regions, making him very accustomed to the ways of conversing. Up front, the leading questions and the theoretical fundamentals behind them were discussed with Shahzeb to ensure he knew what was exactly being asked. Shahzeb understood already that conducting interviews in rural areas is not a simple task, for example, because of unwillingness to answer truthfully to answers. Because of this Shahzeb approached the exact translation of the questions that were asked in a more appropriate form to increase the chances of valid answers, while at the same time also asking other follow up questions that might enrich the content of the interview. Shahzeb also posed as a discussion partner afterwards and has checked the data processing for accordance afterwards. His presence was an immense value that ensured a more valid data retrieval and processing.

6.2.2. Company/Intermediary Questionnaire Y

The Questionnaire Y for researching the construction phase is meant for the ESCOs and the intermediaries and the questions can be found in Section C.2 of the Appendix. Conducting the interview in person always had the preference, however not in all cases this proved possible due to geographical distances, time constraints of participants and the need to retrieve information from multiple sources within companies. Therefore an online sheet file in Google Drive was created, accessible to anyone with the link. This way participants could fill in the questionnaire from another city, with multiple people or across several time periods.The online questionnaire was always accompanied with a telephone call to explain the research in detail.

Questionnaire Y is divided in to five parts. Part A aims to uncover the ex-ante characteristics, as explained in Section 5.5. Part B is composed of questions that tell something about the institutional position of the organisation and some performance indicators. Part C goes deeper into the characteristics of the partnerships that the organisation is having. Part D relates to the Responsible Innovation dimensions and what activities of the organisation contribute to them. Part E asks for more information about the location of projects and if there would be a possibility to visit any.

A - Ex-ante Characteristics

This distinction has not been derived from the Responsible Innovation Systems framework, but flows from the observations made in section 5.5. These questions are not specifically meant to answer the main research question directly, but are rather an addition to provide the participants with additional valuable information, so that they could be persuaded that participating was beneficial for them too. The answers can sometimes be used for extra arguments, but still the results of the ex-ante characteristics have been placed in the Appendix to allow more space for results that directly answer the main research question.

A small explanation might still be valuable for some readers. A distinguish was made between opportunity, necessity and revolving-door entrepreneurs. Necessity and revolving-door firms are more prone to failing, especially in developing countries. This has been captured in the term 'ex-ante characteristics', specific configurations of firms that predict their overall performance already before entering the market. The ex-ante characteristics specify on firms and shall therefore only be relevant to organisations that classify as such, acting (partly) in the industry sphere, therefore part A is left out if irrelevant.

The review by Vivarelli distinguished the most important ex-ante characteristics, which will be included in this questionnaire: *Firm size and age; Credit rationing; Education and human capital; Previous job; Innovation; Motivation for start company; Role of ethnicity* (Vivarelli, 2013)

B - Institutional position & impact

In Section 4.2.1 components of the Responsible Innovation Systems framework have been explained. Relevant things to discover are the institutional sphere(s) of the organisation and what type of innovator it is, like the presence of R&D. This part is further enriched with questions regarding the impact of their products on the market, the society and the planet.

C: Partners

The relations part of Questionnaire Y aims to expose the relevant connections to other actors in the system. A table is used for clarity, with a row for each partner and columns with characteristics of both the other actor and the nature of the colaboration itself. The characteristics are: *type of organisation, year of start collaboration, the frequency of contact, the type of contact and type of relation*.

Type of organisation - Here it is discovered what type of institutional sphere the organisation belongs to, so either Government, Industry, University/Academic, Public/Civil-Society (G-I-P-U) or intermediary. So when does an organisation belong to a certain institution? For this research it is decided to follow the mission statements of the organisations. If the mission of an organisation clearly contains the creation or transfer of political, economic, social or human capital, in these or any other similar terms, the organisation contributes to a corresponding sphere. Since this could largely be done from public information, answers from participants have always been evaluated to suit this definition of sphere contribution and maintain validity of the results.

Year of start collaboration - While the main research question asks for the view on the current innovation system, presence is always constructed from history. Being able to make observations of past configurations of the system is valuable, when relating to the evolutionary principles that are deemed relevant by use of the triple/quadruple helix theory. Simply said: Is the system changing towards a more responsible configuration, or are things worsening? It has an additional benefit of knowing which relations have survived the test of time. Since little research exists on how long it takes for collaboration effects to be noticeable, there is no scientific base for eliminating recent partnerships from the analysis, however it must be noted that these recent connections might have had little influence on the current impact of organisations.

Frequency of contact - From OI it is seen that successful relations are often stronger relations that maintain a stable and intense contact, with a larger amount of knowledge flow between them. The frequency of contact will therefore expose the strength of relations and allows more comparison between relations on this base. Two columns are dedicated to this. One is related to the peak frequency, often happening at the beginning and ends of projects. The other is the normal frequency of contact, that normally would be expected throughout the year. This is to make a better estimation of the relation strength. The options that are presented to the interviewees are daily, weekly, monthly, quarterly, yearly contact and never.

Type of contact - The type of contact is important in the context of conversions between tacit and explicit knowledge, as can be seen in Table A.1 in the Appendix. Informal networks relate more to tacit knowledge, because explicit knowledge tends to appear in formal network structures.The interviewee gets the default choice of formal and informal contact. This is to have a better perspective on potentially under-performing relations. If an entity is receiving tacit knowledge, but more equipped to handle explicit knowledge, the relationship might cost more than it will deliver in any type of value. Later on, this question proves to be questionable in terms of validity, because the definition of formal/informal seemed to be unclear and deviate among participants.

Furthermore there is also a data processing component to this question, combined with the frequency of contact. The decision was made to eliminate a relation from the obtained data if there only was yearly informal contact, because then the relation is not deemed influential enough.

Table 6.2: All default configurations of relations and their default contribution to the Knowledge and Innovation spaces

Type of relation	Knowledge Space	Innovation Space
Supplier	-	-
Customer	-	-
Funding	-	-
Joint R&D	X	X
R&D Outsourcing	X	-
Knowledge Purchase/Sales	X	-
Knowledge Exchange	X	-
Human Capital Exchange	X	-
Strategic Alliance	X	-
Joint Venture	-	X
Licensing in/out	X	-
Co-creation	X	X
Incubator	X	X
Other or multiple	?	?

Type of relations - The type of relation will show what nature the knowledge creation or transfer of the relation really has. From literature in Section 3.2.3 on Open Innovation, a number of possible relations were discovered. Table 6.2 shows the default relations that were expected up front and presented to participants as options. The table also shows how they might contribute to the functional spaces of Knowledge and Innovation of the Responsible Innovation Systems framework. From the nature of the relation type it is derived if there is either knowledge creation or knowledge transfer, resulting in a contribution to the Knowledge Space. If there is combination of knowledge into new products and services, it is a contribution to the Innovation Space.

It is assumed that a supplier relation does not contribute to either knowledge creation of innovation, which also counts for a customer or funding relation. Joint R&D is naturally a combined approach to knowledge creation and has in its nature that there is a combination of knowledge resulting in innovations, which is often the purpose of it and is also the case with co-creation and incubators. R&D outsourcing only contributes to knowledge creation, as the entity does not innovate itself, which also counts for knowledge purchases, sales and exchanges as well as human capital exchanges, strategic alliances and licensing of products. A joint venture is only contributing to the Innovation Space, since new services are created this way, while knowledge creation remains with each of the companies themselves.

This contribution is not a solid stone, since relations might fall under a certain type, but do not operate equally. The default options in the table are therefore always subject to evaluation by consulting an additional column in the questionnaire that asks to explain the relation in a short description. This extra description should also reveal more information on the directions of knowledge transfer, showing if there are two-way channels present. Again, this column proved afterwards to be left open by many participants, making the determination of knowledge directions difficult.

Devoted to electrification as whole of organisation? - It is also often publicly available what an organisation devotes to. Being devoted is measured as energy access or electrification being the main activity of the partner. USAID, for example, focuses on much more then only energy, while CLEAN has a clear focus on energy access. The interviewee is presented with the options yes, no and unknown.

R&D - Does the partner perform any sort of R&D? This is defined as channelled knowledge production within the company, meaning the goal is to create knowledge. This often implies, but not exclusively, that there is some form of explicit knowledge creation. The interviewee is presented with the options yes, no and unknown, but this information has always been checked with publicly information of the

partner.

Based in India - The interviewee is also presented the options yes, no and unknown in this case. A 'yes' is requested when the headquarters of the organisation is based out of India. Again, USAID will not qualify for a yes, where TATA would. This is also evaluated by consulting public information.

D: Responsible Innovation Activities

Naturally, questions should be included that try to uncover the presence of the RI dimensions of anticipation, reflexivity, inclusion and responsiveness. The exact questions can be seen in Section C.2.4. While the inclusion dimension largely should become clear from part C of the questionnaire, the other dimensions are determined like this.

A set of questions, seen in Apppendix C.2.4 was set up asking each participant for their activities on anticipation on future events, in what way they reflect on their position in the system and that of their partners and how they create resources to respond to changing situations. For each participant it is determined in which manner the dimensions can be observed from those questions in the internal processes, as well as within the partnerships they are having. This latest observation will generate evidence to construct the Consensus Space map, eventually leading to the possibility of determining the degree of responsibility in the system.

Additionally, a question about intellectual property has been added, because it is relevant to the conditions for a responsible innovation system. The other conditions are deducted from circumstantial evidence, rather then direct questions.

E: Project Areas

This part of the questionnaire is asked to get an idea of the geographical distribution of activities of the ESCOs, contributing to to Figure 6.2. It also helped as input for the planning of field visits.

Visualisation in Gephi

The results from questionnaire Y are visualised in Gephi. Gephi is an open source computer programme, used for revealing the underlying structures of associations between objects and easy creation of social data connectors to map community organisations and small-world networks. In Gephi, the innovation system is visually build up from the found partnerships in part C of Questionnaire Y. One can create nodes and edges (relations) and apply characteristics to them, allowing the programme to make visualisations that allow for better data interpretation.

The **nodes** get applied several characteristics. The type of institution is noted with a G for government, an I for industry, and U for universities/academia and P for public/civil-society or any combination of those for intermediaries. A boolean (yes/no) field is made for the activity of R&D, the devotion to electrification, the presence of the head office in India and if the node was a participant in the research.

The **edges** are also applied several characteristics. There is always a source and a target, but the direction of the relation is undecided. Next, the weight of an edge signifies the intensity of it, therefore the frequency of contact. This is represented as 0 for never, 1 for yearly, 2 for quarterly, 3 for monthly, 4 for weekly and 5 for daily. There also is an integer field for the year of starting the collaboration. Lastly there are again boolean fields (yes/no) for if its a funding relationship, the contribution the functional spaces of the framework and if the edge was directly researched.

The map is computed with the ForceAtlas algorithm, a linear-linear model where attraction and repulsion are proportional to distances between nodes, scaled for small to medium-size maps and adapted to qualitative interpretation. (Jacomy et al., 2014) The repulsion strength has been set to 2000 and the node overlap prevention mode has been activated. Also a label adjustment layout has been performed to increase visibility. Lastly, colouring is used to highlight characteristics for instant interpretation of the maps created.

6.3. Event visits

A final addition to data input for the case study is what has been learnt during event visits, representing the exploration phase of the collective innovation process. Several insights were deducted from attending those conferences and hearings that have relevance to the rural energy access innovation system. Four events in total have been visited, namely India Smart Grid Week, IVEGOV:Digital India, WWF Climate Solver and a public hearing by the CERC on renewable energy policy. The events are also analysed with the help of the framework.

6.3.1. India Smart Grid Week

The India Smart Grid Week is an event from the India Smart Grid Forum, a government-industry partnership initiative by the Ministry of Power for accelerated development of smart grid technologies in the Indian power sector. The connections to government are very prevalent and the organisation is very involved with the composition of road maps and policy documents. The event took 3 days and contained workshops where international best practices were related to the Indian case. The workshop of Canada-India was actively attended. Additionally there was an exhibition area, where about 40 organisations portrayed their activities on the latest smart grid technologies.

During the workshop and on the exhibition, it was constantly questioned to delegates whether the technologies or approaches were relevant to rural areas. At the same time an approach to government officials was sought, since it could give a lead for government participants in the questionnaire.

6.3.2. ICEGOV:Digital India

ICEGOV is a yearly global event organised by UNESCO in cooperation with governments. In 2017 it was the honour to the Ministry of Electronics and Information Technology for hosting the four-day event in Delhi. The event connects a lot of well-known academics and government officials, among which Prof.dr.ir. Marijn Janssen, head of the Information and Communication Technology section of the Technology, Policy and Management Faculty of Delft University of Technology who chaired a part of the conference.

During this event, two tracks were visited with the themes of transformation and smart cities, villages and regions. Each track contained six presentations on research projects that are active in those fields. Again, an active attitude was taken during these tracks in asking questions regarding the relation to rural energy access. Also the willingness to connect to government officials was expressed.

6.3.3. WWF Climate Solver Workshop

The World Wildlife Fund (WWF) Climate Solver event was attended relatively late in the three-month period in India. The platform serves to promote the use of innovative clean technologies and thereby contribute to reducing emissions and enhancing energy access. It wants to be an interface between low carbon technology innovators and industry associations, investors, government, incubation centres and the media.

The event started with a presentation of last year's winner of the Climate Solver award, namely Simpa (also one of the participants of this research). Then, a panel discussion on the role of finance in the innovation ecosystem was done, with CEO of CLEAN Hari Natarajan as a speaker, who was also personally interviewed earlier. Lastly, an open discussion with the crowd of stakeholders was led by OKAPI Research as a way of input for a research project that tries to define barriers and the status of the energy access ecosystem, ordered by WWF itself.

6.3.4. CERC public hearing

The Central Electricity Regulatory Committee (CERC) held a public hearing for input on terms and conditions for 'tariff determination from renewable Energy sources' regulations. The committee, five experienced policy makers, heard questions of anyone present and willing. A request for a question was done on the list in the waiting room, but during the meeting the openness of the discussion was hugely overestimated. Upon turn the request was cancelled to leave more time for Indian businessmen, officials, academics and civilians, who spend huge amounts of time preparing for this public hearing.

6.4. Summary - on the case study method

This chapter has seen to an explanation of the comparative case study of 3 months field research in India. The input from the case study is a combined approach of 2 different questionnaires and event visits, all relating to the three phases of innovation, namely exploration, construction and implementation. Each phase can accordingly be assessed by determining the components, relations and functions that the framework describes.

The four event visits serve as insights for the exploration phase, since organisations come to these kinds of events to learn about new developments. Also, the top-down role of the institution of government could this way be enriched, since no organisation or individual could be persuaded to take part as participant in the other questionnaires.

Questionnaire Y is a structured interview relating to the construction phase and is done with 17 organisations, being 13 social enterprises and 4 higher level intermediaries. Due to long distances and schedules the interview turned more into a structured online questionnaire, though several could be personally interviewed. The questionnaire consists of five parts, aiming to discover ex-ante, institutional, partnership, responsible and geographical characteristics. Due to several categorised options that were possible for the responses, the data could be used as input for the social network programme Gephi. Through Gephi, the Knowledge, Innovation and Consensus spaces have been sketched for easier data interpretation, as well as numerous other characteristics.

Questionnaire X is a semi-structured interview that was done five times with rural inhabitants and end-users of rural energy technology, relating to the implementation phase. The quest on finding evidence of a responsible innovation system was pursued in bottom-up open discussions with the help a known local interpreter.

7

Results & Discussions

This chapter gives a presentation of the findings that the different parts of the case study could provide. Three different main results can be noted, namely the results from event visits, the structured interviews from Questionnaire Y and the semi-structured interviews from Questionnaire X, respectively found in Sections 7.1, 7.2 and 7.3. Because of the variety of different data, every part will immediately be discussed shortly after the presentation of results, where the elements of the framework will be emphasised. Some discussions will be taken along to the validation and recommendation chapters that will follow this one.

7.1. Event Visits - Exploration Phase

The event visits serve as input on the role of institutions in the system while in the exploration stage of the collective innovation process. Events are arenas where partnerships are forged, knowledge is shared and new influences can be gathered for further innovation. They also have the potential to become arenas where activities that contribute to responsibility are pursued. Four events in total were visited, all with a slightly different objective, but all relevant to the rural energy innovation system.

7.1.1. India Smart Grid Week (ISGW)

ISGW was a 3-day conference on smart grids, where mainly industry and government came together and some universities could be found. However, there is one player they forgot to invite. Civil society actors were no where to be found and the majority of people who were asked about rural applications of the technologies that were presented said that the rural market was not one of the focus areas. Smart grids are the solution to many issues the rural energy market is looking for, so why was the rural part of India silently ignored during this prestigious event? During the Canada-India workshop, the Canadian delegates frequently mentioned the use cases they had for rural areas and how these could be applied to India. However, none of the Indian officials seemed to pick up that stick. Also government officials that were introduced to this research and were asked for a contribution did not find the capacity to do so. After this event the impression was formed that the government is only interested in the urban energy sector, not in the rural one. From a capitalistic point of view this might be justified, since the electricity networks in cities are also still underdeveloped, with power cuts in Delhi happening weekly. Since the amount of people that should pay their electricity bills are much closer together in cities, these are better places to develop first.

Furthermore, the government officials that were presented during the event, all seemed to have a fairly traditional view on the energy sector. One of the top officials that was asked to conclude the Canada-India workshop, held a speech that gave no correct representation of the former four hours and gave the impression he had not comprehended the implications of the knowledge that was shared, since he did not mention one of the lessons the Canadians had tried to give. One of the other government officials in the room claimed that the whole of India would have 24/7 power within 3 years, what looking at the numbers seems tremendously unlikely. It is difficult to be optimistic for the rural areas, where governmental DISCOMs are still the norm, because the leaders of those DISCOMs do not appear to be aware of the changes the electricity system needs.

7.1.2. ICEGOV

ICEGOV was a massive event, organised by the UNESCO and the Ministry of Electronics and Information Technology. The event was mostly a combination of government with academics, but also industry and civil society actors were present as speakers. It is relevant because of the expected innovations in communication technologies like Internet of Things, which can be used with smart meters. Here, a different government presented itself. Inclusion was perhaps the word that was most used in all the speeches and talks. Open government was openly discussed and even an open government platform was launched. Several academic contributions were also made, of which many contained the rural areas as topics. Also reports with sustainable development goals were distributed, where a focus was on the rural areas of the country, constantly calling for unity of the Indian people. How could this view be so different from the other event? The difference was that the ICEGOV event was coordinated from the top of the top level government. That is the place where Prime Minister Modi and his party are setting high targets and ambitious programmes to change India. What ICEGOV showed, was that at the top of federal government a change has started, it just has not reached the rural areas yet.

7.1.3. WWF Climate Solver

The climate solver, organised by World Wildlife Fund (WWF), was the best attempt found to a coherent ecosystem boost. The track exists of a number of workshops, where all SMEs that are battling climate change have been brought together. Also part of the workshop was a research project on the main barriers of the system. Each year a winner of the climate solver award is chosen. This winner gets some expert help in building their business, as well as exposure.

The workshop had a presentation by last year's winner Simpa and industry and government speakers, after which there was a joint discussion with all the present stakeholders. The discussion was a good attempt to create a cooperative working environment, however, unfortunately it failed to become this. It was not a discussion that started, but more a set of loose monologues of men who wanted their voices to be heard. What was concluded from this event, was that a cooperative working session with people in the industry is a very hard thing to do, if the intentions are not clear. WWF tried its best in getting stakeholders to decide on common barriers and share each others lesson, therefore increasing the responsibility in the sector. However, WWF forgot to direct the participants of the workshop towards these goals, leaving an opportunity untaken.

7.1.4. CERC Public Hearing

The chance was taken to attent a public hearing by the Central Electricity Regulatory Committee (CERC). Instantly, the large distance that government has from what is happening on the ground became clear again. A formal setting arised, where the committee was separated from the crowd like a judge in a courtroom. Within the time of two hours, groups of stakeholders in the electricity sector got the chance to discuss their concerns with the latest policy on renewable energy tariffs. A particular group draws an image of how this went.

At their turn, a group of four men came forward with a folder containing hundreds of pages of documents. They had come all the way from Assam, a state in the North-East of India and a seven-hour flight away. They operated small hydro plants as their way of making a living and were highly dissatisfied with the proposed new policy. From their faces you saw the nerves, stressing the importance of these 15 minutes where they got to tell their story. A series of incomprehensible slides followed, that were unreadable on the small screen and contained way too much information. It took the group three times, by different men, to repeat the line of argument, before the CERC started to understand what was being said. After a few minutes of inaudible speaking between the members of the CERC, the chairman told the group that their request would be looked into further and they were questioned to hand over their folder of documentation. In two hours time, about ten of these sessions were done. Ten contributions of feedback, with no possibilities of further discussion afterwards. The curtain was closed and the CERC left the room.

If this is the process that the government is having regarding all their input for policies, it is a small wonder if any of the real concerns happening on the ground will become clear. Another public hearing by the BERC in Bihar was attended by a Rural Spark employee. He reported back that there was only one other attendee and that the BERC actually had no real interest in what they had to say. Multiple comments on policies have been submitted in the past months by the writer of this report, but never has there been any reply or any sign of implementation of those comments in new policy. It must

be concluded from the public hearing visit that the policy making maechanisms of India are not yet ready for a fully working knowledge democracy, where large amounts of data, growing knowledge of the population and fast communications are the norm.

7.1.5. Discussion in framework perspective

Now that the individual events have been explained, the results can be discussed in the structure of the Responsible Innovation Systems framework, being the compenents, relations and functions. Because several aspects will be repeated, also new insights can be generated with this perspective.

Events - Components

Each event can be assessed on the appearance of the institutions as determined through the Quadruple Helix. It is difficult in this context to include intermediary organisations, but rather a contribution to each sphere is found to be done during the events. Table 7.1 shows the results.

Table 7.1: Components observed in the event visits; X = found, - = not found

Event	Government	Industry	Civil Society	Academia
ISGW	*X*	X	-	X
ICEGOV	*X*	X	X	X
WWF Climate Solver	*X*	X	X	X
CERC public hearing	*X*	X	-	-

It appears that only ICEGOV and WWF Climate Solver have fully inclusive setups of their events. ISGW is clearly missing a civil society perspective and the CERC public hearing is missing both civil society and academic influences, while this could also have been different if other people would have raised questions.

Events - Relations

While events are eminently situations where relations are formed, the relations part of the framework is to address knowledge flows, being the influence of Open Innovation. The events can also be addressed this way, looking at how knowledge flows are going through its boundaries, while remembering the distinction between inbound and outbound knowledge transfer from section 3.2.3.

The event organisation itself is considered to be the entity from which the knowledge transfer is analysed, relating to the infrastructure that the event organisation has built around knowledge transfer. Inbound and outbound is therefore captured from the perspective of the event organisation, where inbound means knowledge coming from participants towards the organiser and outbound from the organiser to the participant. In Table 7.2 the results of the direction of knowledge transfers are shown.

Table 7.2: Event knowledge transfer directions - inbound and outbound; X = found, - = not found

Event	Inbound	Outbound
ISGW	X	X
ICEGOV	X	X
WWF Climate Solver	X	-
CERC public hearing	X	-

All events have shown to possess **inbound knowledge transfer**, meaning they gathered perspectives and insights from their participants. Both ISGW and ICEGOV have a strong inbound knowledge transfer by allowing people from all over the world to send in papers, WWF Climate Solver held an open discussion with all attendees that was meant for input of a research project on barriers in the clean energy market and lastly, the CERC was open for questions of any stakeholder influenced by their proposed policy and wanting things to change. **Outbound knowledge transfer**, however, was only seen in ISGW and ICEGOV, where the sent in papers determined the structure of workshop and

presentations that were specifically designed to spread the knowledge on relevant subjects. The WWF climate solver tried to create outbound knowledge transfer by an often found technique in India of a discussion panel of several high positioned speakers. This discussion panel was not a successful way to spread knowledge, since it had no structure and was governed by questions from the audience, that were often widely off-topic and irrelevant. The CERC public hearing was the furthest away from having outbound knowledge transfer, which it also was not meant to be. The CERC took request of willing parties to argue on their comments regarding the pending policy, but did not let knowledge travel the other way, except for some reacting to the arguments. It was a one way street regarding knowledge transfer, not contributing to a participatory policy construction and felt distant from reality, since many potential comments throughout the vast country of India can certainly not be heard this way.

Events - Functions

Events can also be assessed through the functions of the framework, which is articulated in the Knowledge, Innovation and Consensus Spaces, of which the latter shall expose the remaining dimensions of responsible innovation.

The knowledge space is enhanced by ISGW, because of a clear balance between in- and outbound knowledge transfer, coming from the emphasis on scientific publications being submitted and discussed at the event. The same goes for ICEGOV, which even had the overall theme of *"Building Knowledge Societies: From Digital Government to Digital Empowerment"*. WWF climate solver is also contributing to the knowledge space because it had a clear motivation of generating knowledge on barriers for stakeholders in the innovation system, which is still pending to be published. Only the CERC is not contributing to the knowledge space, because the public hearing was only meant for the CERC itself to hear comments on their policy from a very select group of people that was able to travel to Delhi.

The Innovation Space was enhanced by ISGW, due to the hackathon that was organised during the event, asking people to try and hack into a control system used for large energy networks called a SCADA, promising a prize for the best submission in the contest. This is a clear example of combining knowledge to create new applications. With ICEGOV, similar workshops were held with an example bearing the name "*How to benefit from FIWARE open platform to accelerate development of innovative smart city services*". At the WWF climate solver and CERC public hearing, no evidence of knowledge combination leading to innovation was discovered. Table 7.3 shows the contribution to the spaces of the events in an overview.

Table 7.3: Events contributing to the Knowledge and Innovation spaces; X = found, - = not found

Event	Knowledge Space	Innovation Space
ISGW	X	X
ICEGOV	X	X
WWF Climate Solver	X	-
CERC public hearing	-	-

The Consensus Space is formed whenever the dimensions of anticipation, reflexivity and responsiveness are found among the activities during the events. Table 7.4 shows for each event whether the dimensions were found to be enhanced by activities during the event, with also a representation of inclusion that was already found in the components element.

For ISGW, anticipation was certainly touched. Not only did the speakers have subjects that were relating to futuristic technologies, but also a daily event newspaper was distributed in which upcoming policies were discussed on the effect they could be having on the sector. Inclusion was already seen not to be sufficient, since the presence of civil society actors was little and taking into account of rural populations was not being done. Reflexivity was enhanced by the multi-disciplinary workshops, where heads of utilities could learn lessons from smart grid practices in other countries, such as the US, Canada or Sweden. Responsiveness was explicitly reached by a clear thematic research agenda,

Table 7.4: Dimensions of RI in events; X = found, / = partly, - = not found

Event	Anticipation	Inclusion	Reflexivity	Responsiveness
ISGW	X	-	X	X
ICEGOV	X	X	X	X
WWF Climate Solver	-	X	X	/
CERC public hearing	-	-	X	-

a workshop on standardisation and the release of a smart grid handbook for regulators and policy makers, next to an advanced metering infrastructure roll-out plan during the inauguration of the event.

During ICEGOV, anticipation was embedded in most of the sessions throughout the four days of the event, such as the session *'Transformation'*. The selected papers had a large degree of future visions, where the presentation under the name *'How to Become a Smart City? Balancing Ambidexterity in Smart Cities'* was only one of the many that presented different scenarios for development of communities. Inclusion, as was seen in the components, was fully reached, containing all institutions of the Quadruple Helix. Reflexivity, like anticipation, was a general theme in the convention, because the opening speaker being Ravi Shankar Prasad, the Honourable Minister of Electronics Information Technology, did a presentation with the title *'From Digital Empowerment to Sustainable Development: Lessons from India'*. Lastly, responsiveness was reached similarly as ISGW, with special workshops on standardisation and the release of a roadmap towards meeting sustainable development goals in India.

WWF Climate Solver did not show any structural signs of anticipation. Inclusion, however, was fully reached as seen in the components part. Reflexivity was also seen, because a section of the event was dedicated to an overview of the cleantech ecosystem in India and the discussion between attendees that was meant to expose barriers that people are facing. Responsiveness was not found during the day itself, however, this could still come if the results from the research project that was determining the barriers comes available.

The CERC public hearing shows the least signs of responsibility. No anticipation, no full structured inclusion, no responsiveness. Only reflexivity was enhanced by discussions on the policy from the perspective of the attendees who filed questions and remarks. However, it shows that the policy making mechanism of the government is not behaving in a manner that allows for a responsible innovation system to thrive.

7.1.6. Events - Conclusion

The framework has shed the events in a light regarding their contribution to a responsible innovation system, by analysing the components, the relations (knowledge transfer) and the functions they fulfil. Apart from that, also a more general impression can be given on what has been seen. This is especially important for a perspective on the role of the government, since no governmental actor could be persuaded to participate in the other data collection methods.

The Framework Perspective

The components element of the framework, relating directly to inclusion, shows that only two out of the four events are fully inclusive. ICEGOV and WWF climate solver have structurally included all institutions in the Quadruple Helix. ISGW is clearly missing a contribution by civil society actors or other representatives of the population. The CERC public hearing has only structurally included itself as government actor and is fully dependent on who shows up with comments on policy.

The relations element of the framework has shown that all events were collecting knowledge through inbound knowledge transfer processes, but only ISGW and ICEGOV provided attendees with new knowledge through structured outbound knowledge transfer processes. WWF climate solver does have the infrastructure to create outbound knowledge processes and perhaps also the wish, however, should structure their event more towards this in order for it to become beneficial. The CERC public hearing is particularly deprived of a two way knowledge transfer channel and apart from the draft policy itself, no insight was given in how, why or what was done to construct the policy, failing in taking into account their stakeholders.

The functions show that the events that provided a two-way knowledge flow (ICEGOV/ISGW), also managed to combine knowledge within the boundaries of the event, because of a clear contribution to the Innovation Space. Also the Knowledge Space was sufficiently addressed, because of the addition of

research papers as a deliverable of the event. WWF climate solver only contributed to the Knowledge Space with a research project governed the event, but there was no clear combination of insights with new applications visible. The CERC public hearing did not contribute to any of the spaces, making a poor image for the governmental policy making processes. When the Consensus Space was analysed, only ICEGOV proved to be touching all the RI dimensions. It is closely followed by ISGW, that needs to work on further inclusion of civil society, before full responsibility can be appointed. Both WWF climate solver and the CERC have to revise the setup of their events tremendously before responsibility can be reached.

What these results show is that tools for ensuring responsibility exist for organisations that are in the early implementation phase of their innovation process, since ICEGOV has touched all aspects of what is asked in a responsible innovation process. However, ICEGOV was a one-time event for India, since next year it will be held in Ireland, leaving a gap for the future. It is up to ISGW to take over the role of being an arena where full responsibility can be reached, by including more civil society in their set up of the event. WWF climate solver is fully inclusive, but needs to find ways to set up a two way knowledge transfer channel, before it can start contributing to the Innovation Space, while also focusing on the anticipation and responsiveness dimensions. The CERC public hearing appears the furthest away from responsibility, without contributing to the Knowledge and Innovation Spaces and only marginally to the Consensus Space, while having a static one-way inbound knowledge transfer process, that is not structurally inclusive. It raises questions about the responsibility in the role of government.

The Role of Government

This role of government can be extended by additional insights from the events, partly necessary since direct participation was not established with this institution in the other data collection methods. Two sides have been seen. The way that government currently works and the way the government wants to be.

The ICEGOV event attracted top level federal government. India's progressive side showed itself, with a constant mentioning of inclusion of the poor into the modern world, hence the slogan 'Digital India'. However, at the ISGW event, the current state of government in the energy sector showed no signs of inclusion of the rural areas. Rather the opposite was true, since the directors of public utilities and regulators appeared to have little interest on rural activities. This observation was done again when visiting the public hearing of the CERC, which should pose as public participation in policy making. Sadly, the public hearing is far from being a move towards a participatory society, due to the high threshold of coming to Delhi and the large distance of the committee from activities on the ground.

Government appears to have a long way of descending from the ivory tower, however, it is taking its first steps.

7.2. Questionnaire Y - Construction Phase

After the exploration phase, the construction phase becomes apparent in innovation processes. The construction phase is done internally in organisations, but also reveals itself in collaborations between actors in the system, each taking a piece of the puzzle of the collective innovation process. Questionnaire Y addresses organisations and their partners that participate in the construction phase and tries to reveal the degree of responsibility for both the internal and shared processes. The degree of responsibility in collaborations was defined as the percentage of collaborations that contain elements of the dimensions of Responsible Innovation. This excludes inclusion, which is found over a multitude of relations and is separately addressed. Additionally, several other observations are derived from the results.

Questionnaire Y was presented to 17 organisations in order to expose *ex-ante, institutional, partnership, responsible and geographical characteristics, respectively divided in parts A, B, C, D, E.* Part A, B and D are resonating with the components element of the framework, part C with the relations element and part D with the functions. However several observations proved to be covering several parts and several elements of the framework, which might explain why the distinction of framework elements could prove somewhat hidden during this section. In the discussion at the end, however, the structure of the framework is followed again.

Unfortunately, not every organisation filled in the questionnaire to the fullest, despite frequent requests to do so. The response to the different parts has been given in Table 7.5. In the table, an 'X' means complete answers, a '/' means incomplete answers and a '-' means no answers to the specific part at all. Whenever an organisation is presented in bold letters, it means that the explanation of the research was done in person. If the name is also underlined it means the questionnaire was done in person. Therefore, if not underlined it means that the questionnaire was fully filled in online by the participant. If not spoken in person, there was always an extensive phone call made with the organisation.

Table 7.5: Parts of Questionnaire Y filled by participants; X = complete, / = partly filled, - = no response; **bold** = personal explanation; underscore = personal interview

Organisation/Parts	A	B	C	D	E
Claro	-	-	X	-	-
DESI	/	/	X	-	-
Gram Oorja	X	X	X	/	X
Gram Power	X	/	/	X	X
Mera Goa Power	X	X	/	X	X
Mlinda	X	X	X	X	X
ONergy	X	X	X	/	X
Piconergy	X	X	X	X	X
Rural Spark	X	X	X	X	X
SELCO	X	/	/	X	X
Simpa	X	X	X	X	X
Vayam	/	/	X	/	X
Mrida	X	/	X	X	X
CLEAN	n/a	X	X	X	n/a
J-Pal	n/a	X	X	X	n/a
Shakti Foundation	n/a	X	X	-	n/a
TERI	n/a	X	-	X	n/a

7.2.1. A - Ex-Ante Characteristics

The ex-ante characteristics, as explained in Section 5.5 have been obtained to gave more dimensions to the components part of the framework. It allows to better compare specific cases, but ended up serving mostly to deliver something more tangible for participants in the research in return for their time and effort. However, because the research question is not directly answered by the ex-ante characteristics and for sake of clarity, the results of part A have been moved to the Appendix Section D.1. For any participant reading this report, that section would be worth investigating. Further on in this report, whenever there will be made lines of argument with data from this part, there will always be made a reference to the Appendix.

7.2.2. B - Institutional position & impact

This part of the questionnaire asked about what institutions the interviewees are part of. It helps to assess the components part of the framework. The participants were also asked what their impact is in terms of energy access or renewable energy capacity addition or environment protection, for a slight performance indication. Figure 7.1 gives an overview of the institutional areas that were interviewed.

Institutional Position

It appears that all 13 ESCOs are part of the intersection with the Industry and Public spheres (IP). They are so-called social enterprises. Technically, this is an intermediary, but because of the dominance of the social enterprise group, they will be separately addressed and in the rest of this report, the term intermediary will not apply to the social enterprises anymore. Their missions are largely based on doing social good, while maintaining an economic sustainable business model. Because of the many IP interviewees, a bias is created to presumably find more I and P institutions. To counterweight this

bias, four other organisations are interviewed too. In the validation chapter some more words on the bias that is still left will be said.

As for the four other organisations, they are higher level intermediaries. The Energy and Resources Institute (TERI) and The Abdul Latif Jameel Poverty Action Lab (J-PAL) are both active in the spheres of Government, Public/Civil-society and University/Academic (GPU). They are creating political, social and human capital, as a clear part of the objectives in their mission statements. Both result from a more human capital creation origin, but have developed to a multi-institutional organisation of level 3 intermediaries. Both Shakti Foundation and CLEAN have even become level 4 intermediaries, containing all defined institutions of Government, Industry, Public/Civil-society and University/Academic (GIPU) and similarly creating and/or diffusing political, economic, social and human capital as part of their mission statements. It must be noted, a full time job is a full time job and evidently their institutional activities are heavily diluted and maybe not recognisable with traditional single-sphere institutional activities.

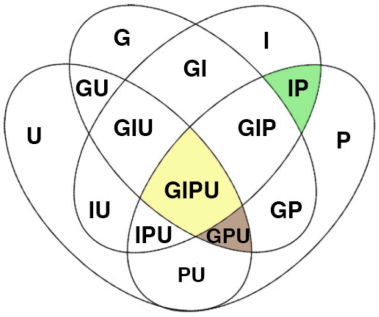


Figure 7.1: Institutional configurations that have been interviewed: 13 IP; 2 GIPU; 2 GPU

Impact

While responsibility stays an intangible phenomenon, it was presumed worthy for this research to have data on more tangible aspects of innovation, like impact made. One can innovate until eternity, but if it does not contribute to certain objectives, there is little use. So how is impact measured? For this part, because of the social enterprises, impact on four common found objectives was asked to the IP organisations. Number of people reached, profit made, number of renewable energy capacity installed and tons of CO_2 that were saved due to their products.

Unfortunately the latter three resulted in answers that were examined to be of a dubious validity, due to some unrealistic numbers, as is further explained in Chapter 8. It was decided to only address the question of how many people were reached by the organisations. The data on impact is presented in Table 7.6.

SELCO, Simpa and ONergy come with impressive numbers. Especially ONergy has reached this fairly quick with a relative small amount of employees, because Simpa has also reached it in a small amount of time. Some growth was seen with the middle group, but there are still a few organisations waiting for large scale growth. In the next parts, these insights shall be coupled with the activities relating to responsibility of the organisations, creating some additional insights.

Table 7.6: Ranges of number of people reached by the ESCOs

Number of people reached	Organisation	Total
<1000	Gram Power, Piconergy, Rural Spark	3
1001-50k	Mlinda, Mrida	2
50k-200k	Claro, Gram Oorja, Mera Goa Power	3
200k-500k	Simpa	1
500k - 1 million	Onergy	1
>1 million	SELCO	1

7.2.3. C - partnerships

The most important task of this subsection is to expose the manner in which inclusion is found within the system and how knowledge flows are going. With which institutions do actors connect, what characteristics do partners possess and are there gaps to be filled? Also, what types of partnerships exists and what types of knowledge are exchanged between them? Is there combination of knowledge resulting in innovation? Essentially it will be possible to derive, with use of the Responsible Innovation Systems framework, whether the different institutional capitals (political, economic, social and human) are sufficiently created, included and diffused through the system. While the influences of Open Innovation ask for the difference between inbound and outbound knowledge flows, the responses from participants did not allow for sufficient consideration of this, being the reason why this is left out.

This part of the questionnaire was able to generate a large range of visualisations through the open source network programme of Gephi, based on the relations with partners that the participants have revealed. Several characteristics of the nodes (components) combined with the characteristics of the edges (relations) within the system were explained in earlier Section 6.2.2. The characteristics of the nodes are *R&D perfomer, the devotion to electrification, the presence of the head office in India and the institutional configuration*. The partnership characteristics are based on their *start, strength, the type of contact, type of partnership and contribution to the functional spaces of the framework*. Not all the maps that could be created directly serve to answer the research question, therefore a great number has been moved to the Appendix D.2. However, it is important to realise what one is looking at, which urges to explain.

Important to note is that every actor in the visualisations, starting with Figure 7.2, has at least a direct connection to one of the researched organisations. Almost 7% of the nodes and 60% of the connections in the system are directly researched with the participants, shown in green. The others, shown in yellow, are not researched. The nodes are the partners of the questioned organisations and the participants themselves. The interconnections between unresearched nodes were retrieved from public information like websites and reports, exposing 'partners of partners'. This was done to better represent potential knowledge flows and more interconnections in the system. In Gephi, these additional connections have all been set to a default relation strength of 'yearly contact' to be able to showcase, but not influence the graph too much. Those relations have not received any other characteristics, except when the public information clearly stated more information, like a funding relationship. The labels in the map contain the name of the organisation and the institutional configuration that it has. A bigger node means it has more connections in the system and a thicker line means a more frequent contact. Within the figures, statistics are sometimes added where null and false both mean the same. Null appeared whenever a box was not checked, while false appeared when a box was checked on and off.

At first, or maybe after above description, the maps may seem somewhat bulky and an overload of information. However, Gephi promised to be useful for exploratory work and kept its promise. Exploration is started at the centre and there is positioned the big node of The CLean Energy Access Network (CLEAN). This organisation will be extensively referred to in these lasts parts of the thesis and is important to remember. It is a young (2014) construct from a round-the-table consensus forming of a large group of stakeholders, representing all the institutions. Within CLEAN's activities all the values and goals of those institutions are included and it is therefore a GIPU actor. CLEAN connects with almost all the other researched nodes, most of which are social enterprises (IP). CLEAN itself has also participated in this research.

It can be noted that Pollinate Energy and D-light are fairly well connected but not researched, which is because they had originally agreed to participate, but either did not provide the data or eventually refused. The work done on them has nevertheless been included, even though the relations themselves have not been researched. But what can we now make of this spiderweb of interconnections? The challenge of making sense of all this information remains. With the help of colouring the nodes and edges in Gephi, the maps throughout this section have been clarified.

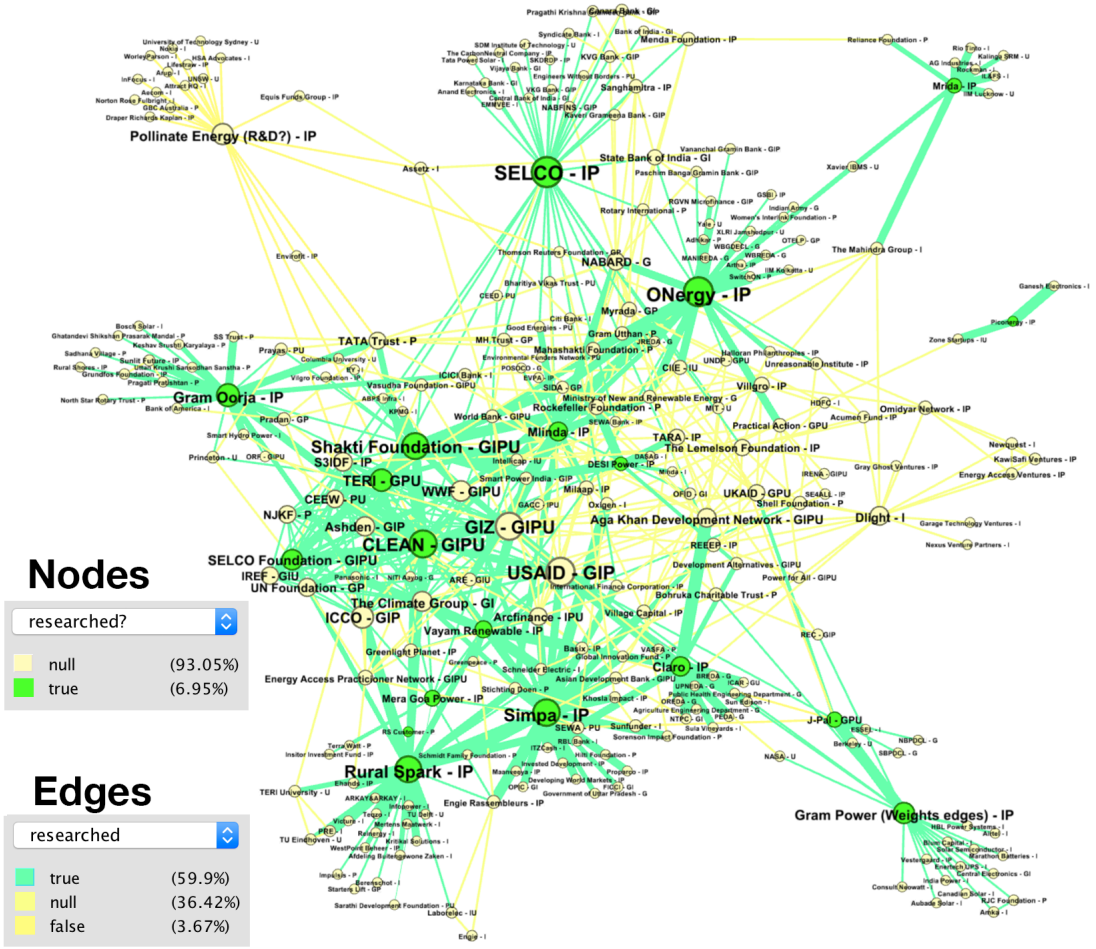


Figure 7.2: All discovered nodes and relations in the system; green directly interviewed or researched; yellow not researched

Institutional Map

As was explained in 4.2.1, a total of 15 institutional configurations are possible in the Responsible Innovation Systems framework. The institutional map shows in what degree the different institutional configurations are included in the system. What would be helpful is to have a benchmark of what the optimal configuration of an innovation system is or should be, however such information was not discovered during this project. What can be done is analyse what institutions are present and perhaps more importantly, which are not so frequently appearing. Figure 7.3 gives the visual representation based on institutional configuration.

The most frequent types are I, IP and P, meaning that there are relatively little government and university actors. This is not surprising, since IP actors have provided the lion share of the data input. This means that the data should be biased to show more I and P, due to expected institutional closeness. From the bias caused by the starting point of interviewing stakeholders, one would expect university and government to be weaker presented, but there does seem to be hints of a consistent lack of human and political capital creation and diffusion in the exposed system. Of the 6 least apparent configurations, 5 are partly U and 4 are partly G. The least apparent configuration is GU. The lack of intermediaries is especially alarming, when it is remembered that intermediaries are often the key to knowledge transfer between institutions. When they are not there, the institutions often operate on their own island, making the configuration of the innovation system one that can not reach systemic responsibility, due to a lack of shared activities.

While the spiderweb can surely show a lot of information when one knows what one is looking for, a

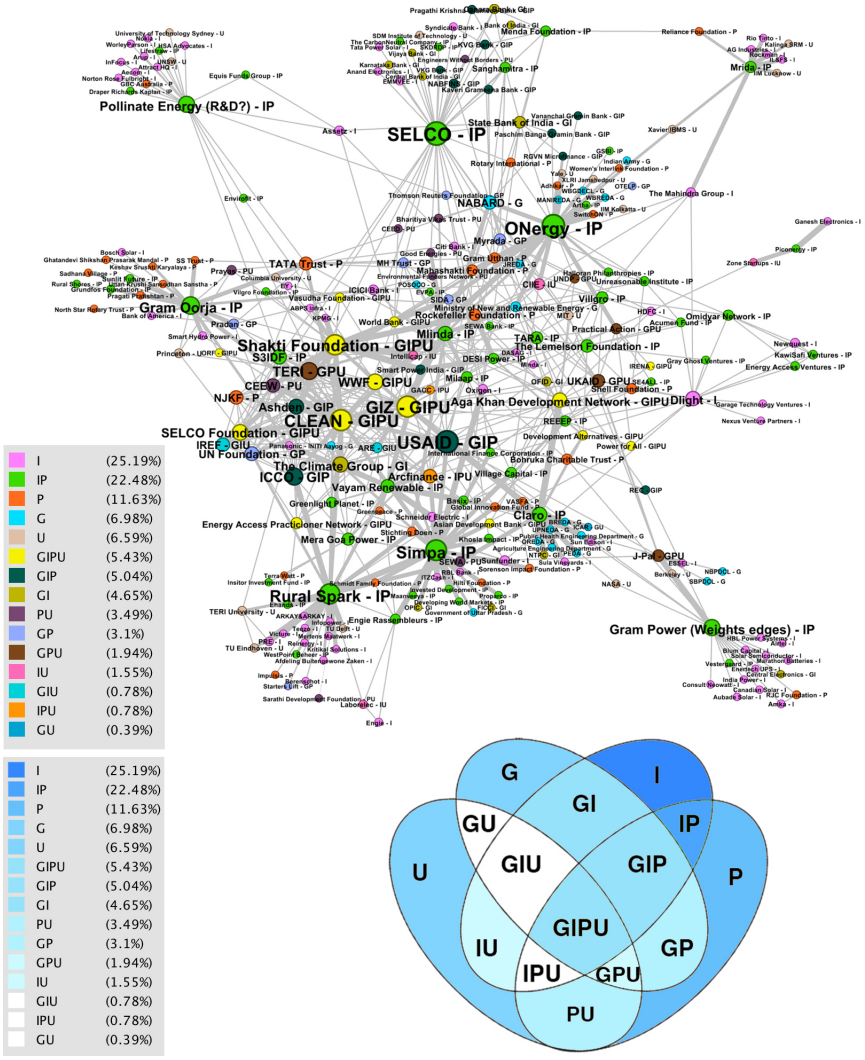


Figure 7.3: The institutional distribution of all determined stakeholders

more specific data representation can be done in the form of a categorisation of relations per participant. This will show in what manner the organisations have addressed the RI dimension of inclusion in their operations. In Table 7.7 the specific connections of the participants have been separately presented.

Before the social enterprises are further examined, the bottom three organisation in the Table are explained. Where bias towards I and P actors with the IP participants was expected, the higher level intermediaries, with a more central and diverse institutional configuration than the IPs, should provide less bias towards specific institutions. CLEAN, J-PAL and Shakti have obligations in the institutions of government and university too and it should be expected that G and U actors can be found with them, to be fully efficient in their own objectives.

However, also here there is little connection to the spheres of G and U to be found. CLEAN does not connect to any university and Shakti does not connect to any government party, which raises questions on how they manage to diffuse political and human capital in the system. They do connect to several intermediaries, but considering the centrality and importance in the system, one would expect more direct involvement with government and academia. It can now be more surely said that strong and responsible spheres of government and university are missing in the found system, since they are not included in the processes of important intermediaries.

Table 7.7: Connections of participants to specific institutional actors

Organisation	G	I	P	U	GI	GP	GU	IP	IU	PU	GIP	GPU	GIU	IPU	GIPU	tot.
Claro	6	2	1	-	1	-	1	1	-	1	1	-	-	-	3	17
DESI	-	2	1	-	-	-	-	1	-	-	1	-	-	-	2	7
Gram Oorja	-	5	8	1	-	1	-	3	-	1	-	-	-	-	4	23
Gram Power	-	11	2	1	1	-	-	-	-	-	2	1	-	-	1	19
Mera Goa	-	1	1	-	-	-	-	3	1	1	2	1	-	-	1	11
Mlinda	4	-	1	-	2	-	-	2	-	2	1	1	1		2	16
ONergy	7	-	6	4	1	2	-	5	1	-	3	3	-	-	2	34
Piconergy	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	2
Rural Spark	-	10	2	3	-	1	-	7	1	1	1	-	-	-	3	29
SELCO	-	4	1	2	6	2	-	9		3	7	-	-	-	2	36
Simpa	1	4	5	-	3	-	-	9	-	1	1	-	-	1	4	29
Vayam	-	2	2	-	1	-	-	3	-	1	1	-	-	-	1	11
Mrida	-	5	1	3	-	-	-	-	-	-	-	-	-	-	-	8
CLEAN	1	1	2	-	1	1	-	12	-	1	3	1	1	2	5	31
J-Pal	2	1	-	2	-	-	-	2	-	1	1	-	-	-	-	9
Shakti	-	3	2	1	1	2	-	5	1	2	3	1	1	-	5	27
Total	21	52	35	17	17	9	1	62	5	15	27	7	3	3	35	309

The individual connections of the social enterprises also bring to light several failures when aiming for a responsible innovation system. The relations with different institutions vary enormously between the participants. In the public sphere Gram Oorja, for example, stands out with a total of 8 P's in their direct network, while most others only couple with one or two. In general most participants, except for Piconergy, couple with a P entity. Within connections to the industry sphere there are also some large differences, but overall the industry sphere is also responsibly included with Mlinda and ONergy as exceptions.

Things start to become more interesting when looked at the role of universities. A total of 17 connections appear, of which is found that only 7 are Indian universities, seen from in Figure D.1. Of those 7, only 2 are engineering universities. For perspective, there are as much Dutch technical universities in the system as Indian ones. Moreover they do not appear very central in the system, often only connected to one other node. Currently the most important contribution to human capital seems to come from TERI (university) and a few research institutes. Many of the participants have no direct contact with a university and limited other forms of connections to human capital creation organisations. Simpa, for example, only connects to a PU and IPU party (apart from the GIPUs) who both not originate from the U sphere. Looking at Simpa's expansion, they might get problems attracting the right employees in the future, if they do not increase the connection to human capital. Simpa is not alone in this and it seriously poses doubts about the human capital that the social enterprises have access to and their future ability to catalyse growth with the right crew on the ship.

For the government sphere other interesting observations can be done. The number of pure government organisations is comparable to the number of universities, but they are strongly clustered around a few organisations and much more intermediaries that operate in the government spheres can be found. Only a Claro, Mlinda, ONergy and Simpa really have direct government connections. SELCO and ONergy work a lot with State Banks (GI) and government owned grameen banks (GIPs), which are banks that serve the rural poor through micro credit, which concept won the Nobel peace prize in 2008. (Bayulgen, 2008) One actor that was expected to be highly involved is The Ministry of New and Renewable Energy (MNRE), but seems to be particularly poor connected, with only Mlinda and ONergy that have direct contact to it. Simpa is only active in one state, but also has strong relations with the State government of Uttar Pradesh. Here the ex-ante characteristics of Section D.1 become relevant. It becomes clear that the well-performing organisations, in terms of growth and impact, are the ones that have strong government ties. All the other social enterprises have to rely on intermediaries, of which was seen that they often do not connect well to government either. Political capital is therefore poorly diffused in the system, which would explain why the amount of time for policies to get a grip takes so long, since

MNRE's 2016 drafts are still in draft.

An observation that must be pointed out is the presence, or rather absence, of DISCOMs, State Nodal Agencies (SNAs) and Energy Regulatory Committees (ERCs), respectively the governmental organisations that should be working in the field to increase energy access and create the policy environment around it (see Section 5.2.2). Gram Power has mentioned to sell smart meters to DISCOMs and J-Pal has some DISCOM connections, however most other participants have not mentioned contact to the distribution segment. Furthermore, it is illustrating that the SNA in the state of Uttar Pradesh, the Uttar Pradesh New & Renewable Energy Development Agency (UPNEDA), is only connected to Claro, while that state has seven other active participants in the area, as was seen in Figure 6.2. The same goes for the BREDA (SNA entity of Bihar) and other states. Of the ERCs there is neither a state committee, nor the central committee present in the circumventing system of the participants in this research. Because these ERCs directly make policies on rural energy technology and even call for stakeholders to come to their meetings, it remains a mystery how they are currently making stakeholders aware, let alone include them in the policy-making as well. From the failed attempt to meet stakeholders at the public event in Bihar of the BERC and an experience of a public event at the CERC in Delhi, that is presented in Section 7.1, more evidence was collected of the failing role of government to actively diffuse political capital and create a responsible innovation system.

Two other governmental organisations are worth noting, namely the Niti Aayog and the National Bank for Agriculture and Rural Development (NABARD). The first will be more extensively discussed in next section, when the anticipation dimension of RI becomes relevant. The NABARD is owned by the government for 99,6% and the Reserve Bank of India for 0,4% and arguably rather a GIP configuration than G. As one of the few exceptions in government it has proven itself an important knowledge platform within the micro finance world and of all governmental parties has managed to get itself fairly well connected in the system.

What might surprise is the large amount of GIPU actors in the system. In the interviews with CLEAN and Shakti (both GIPU) was discovered that the reason of them becoming level 4 actors was the weak institutions that initially surrounded the innovation in energy access. J-Pal (GPU) gave similar observations, that due to a lacking policy environment they felt forced to add the creation of political capital to its mission. Another observation is the centrality that the questioned GIPUs have, which according to their cross institutional activities one would expect. In the recommendation, some suggestions are done for further research to examine more of these GIPUs and the networks around them.

Indian organisations, devotion, funding, R&D and strength of relations

The nodes and relations in the system have received the following characteristics: *Is the head office in India?; Is the organisation fully devoted to energy access; Is it a funding relation; Is the organisation performing R&D; How strong is the relation?*. Five separate maps could be created, retrievable in the Appendix from Figure D.1, D.2, D.3, D.4 and D.5. Their relevance to a responsible innovation system lies in the argument that each characteristic can have a contribution to responsiveness.

From all nodes, 60% has its roots in India, the rest are international organisations. There is not a single international G type in the system and in the I, GI and GIP types the Indian organisations are over-represented. In all others the divide between national and international is more or less half-half, except for universities, which are more internationally oriented. More importantly maybe, the central actors in the system are largely from Indian nature, visible in D.1. Only GIZ, USAID and WWF are foreign parties with a lot of influence. The system seems to be well balanced and protected from international drawback, or national set-back and is therefore more responsive and responsible.

The percentage of organisations that fully devotes to energy access is about 30% and again it seems that most central players are part of this group, except for GIZ, USAID and WWF. In Figure D.2 it shows that the core of the system at least has a focus on energy access, backed by a few very well-positioned multi-agenda parties. With the large diversity of technologies and institutions coming together, it is only logical that not 100% of the system is only looking to energy access problems. However, the large number of devoted to energy access makes the system seem more responsive to changing priorities of actors in other systems and thus responsible.

In the ex-ante characteristics in the Appendix D.1 can be seen that there is a large diversity of funding possibilities for ESCOs in India. The funding map drawn in D.3 also shows the large number of funding relationships, where about 25% of all relations contains a funding component. Three organisations stand out in the web, namely USAID, Arc Finance and Shakti foundation. They provide a far above average amount of funding relations to the network, therefore presumably being a huge impulse to the system. The current uncertainties of the future funds coming through USAID, because of changes in policy in the US, can have a great impact on the system should be a point of discussion. Another interesting funding actor is Milaap, who serves as a crowd funding website for rural development projects and has managed to get quite a central role. Social enterprises, however, do not use Milaap to the fullest yet. When there are more means to invest with, the system becomes more responsive and therefore responsible, which appears to be the case here.

Now for the R&D map, found in Figure D.4. A critical mass of R&D performing actors is needed for a responsible innovation system to exist. Furthermore, with more R&D, therefore more knowledge, an organisation has a larger capacity to deal with new situations. Through R&D, arguably other dimensions of RI are also increased. It is found that more than 50% of the actors are doing some form of R&D and therefore structural knowledge creation processes. Especially the central actors are mostly active in this, making knowledge transfer in theory more easily as well. Before that can happen, however, relations need to have sufficient strength.

For knowledge transfer to be optimally exploited, strong relations and frequent contacts are necessary. In the map presented in Figure D.5 the researched relations of participants are shown combined with the frequency of contact characteristic. The connections in pink resemble relations that have at least monthly contact (noting that SELCO and Gram Power did not provide this information). Two important observations can be noted here.

The first observation again relates to the important roles of Shakti Foundation and CLEAN as GIPUs. Through their frequent contact moments with the system actors, they manage to glue the system together and allow for channels of knowledge transfer that would otherwise be absent. The second observation relates to actors that are probably not benefiting optimally from knowledge creation in the system, such as Mrida and Piconergy. There are no interconnections of strong contacts visible between them and the rest of the system. Therefore new knowledge created in the centre will most likely take a lot of time to diffuse to their channels. Also J-Pal, even though internationally they might have great connections, locally they do not seem to be optimally connected to the system. Still they connect with DISCOMs, which not many actors do.

The rest of the system seems to be operating in a good manner, both having strong connections in the centre of the system, as well as at the outside of it. This prevents knowledge diffusion to result in an echo-chamber, as was mentioned in Section 3.2.3 that such would lead to sub-optimal performance. (Pentland, 2014) The larger part of the system is therefore responsive enough in terms of relation strength and knowledge diffusion, if one would assume that monthly contact is sufficient for proper diffusion of knowledge.

The Functional Spaces

The function of a responsible innovation systems is to see to responsible generation, diffusion and use of knowledge and innovation, which is realised through articulation of the Knowledge, Innovation and Consensus Spaces. In Table 6.2 of previous chapter, the default contributions of the different types of relations to the spaces were presented. Similar to the other visualisations, those spaces can now be shown, with the information the participants have provided about their relationship characteristics. The Knowledge Space shows how 'open' the knowledge flow within the system really is. The Innovation Space actually shows how this knowledge is being combined into new practices were multiple entities co-create. Eventually, the Consensus space will lead us towards where the dimensions of a responsible innovation system are applied. Because of the possible confusion of visualisations and tables through these texts, the data on individual relations of the participants is presented tables in Appendix D.

The Knowledge Space is shown in Figure 7.4. The connections in blue show every relation between

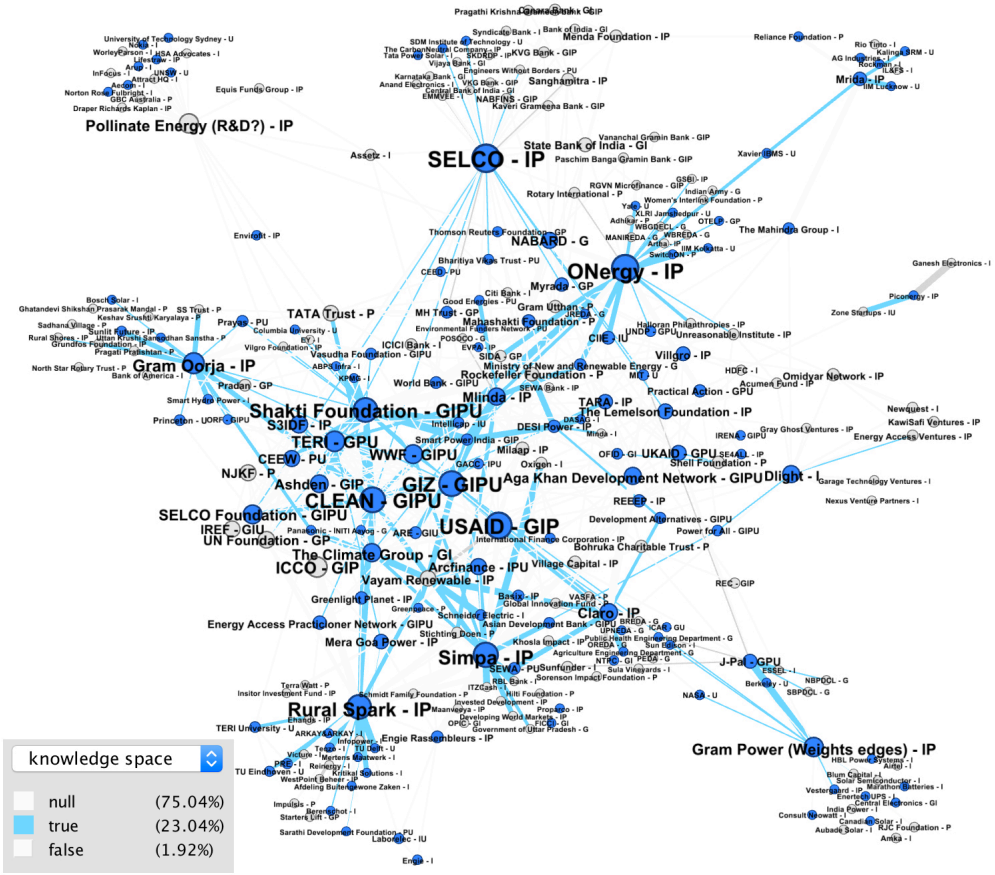


Figure 7.4: The Knowledge Space

actors that involves either shared knowledge creation or knowledge transfer. About a quarter of all found relations contribute to the Knowledge Space, meaning almost half of the directly researched relations. An important finding is that more or less all actors are interconnected in terms of potential knowledge diffusion, except for Piconergy, who again stands isolated. Mrida now seems connected, but when relating to the previous relation strength map, this knowledge transfer channel is probably not frequently used. All other actors are at least connected in knowledge transfer channels to the centre of the system, but for Claro, Gram Power and a bit for Simpa, it can be noted that there exists relatively little knowledge transfer with their relations that are more outside of the system, potentially creating that echo-chamber of recurring knowledge and also preventing their partners to be maximally aware of the latest developments.

Table D.6 in the Appendix shows the individual connections of the participants that contribute to the Knowledge Space. Only 8 out of 35 connections to P of the interviewees contribute to the Knowledge Space. In total that is less then universities do, despite their lower number of total connections. The transfer of social capital is, therefore, leaning immensely on intermediaries, especially the social enterprises in the IP segment, who are already struggling to even stay economically viable, as was seen from the ex-ante characteristics on credit in Appendix D.1. Furthermore, there exist a lot of knowledge creating actors (the blue nodes) that are not interconnected in the Knowledge Space, but do provide valuable knowledge. An example is Practical Action, a UK-based research organisation, that delivers interesting reports on energy access. Of course, more research on these specific actors might reveal other relations that would add to the image, as is suggested in the recommendations.

The Innovation Space in Figure 7.5 gives a more sober image, being the least developed space

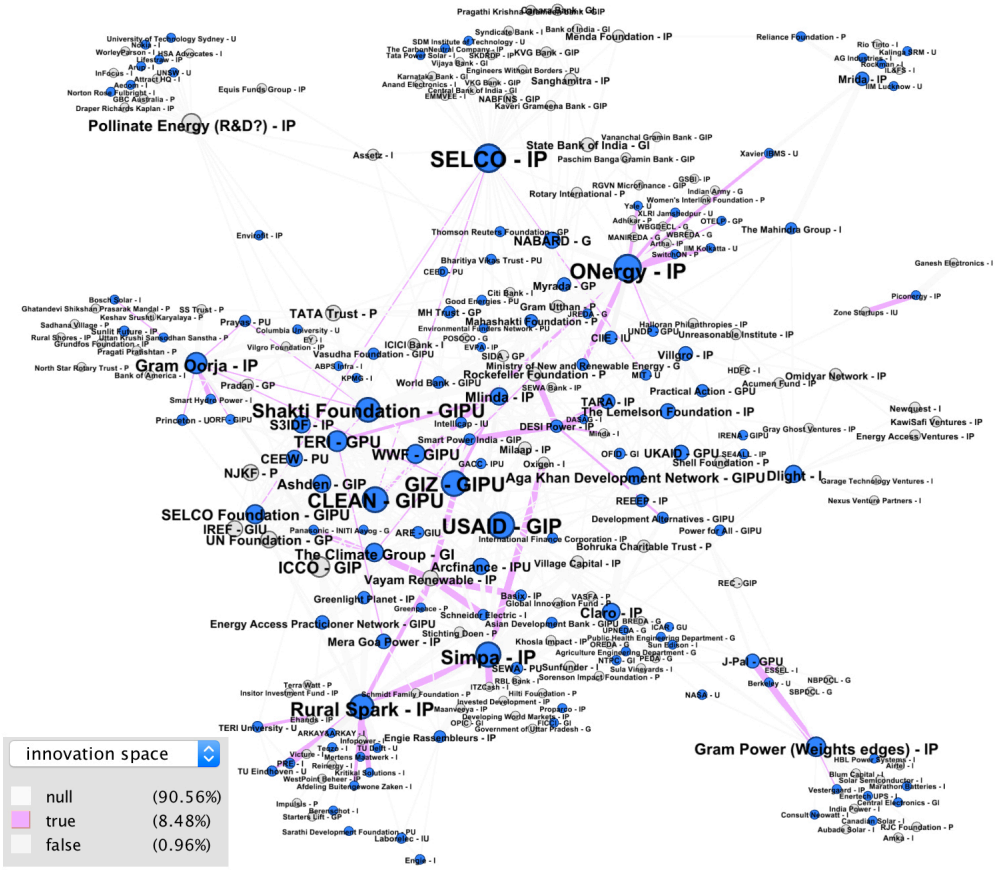


Figure 7.5: The Innovation Space

of the three. Less than 10% of connections are based on the combination of knowledge that might result in innovation. Where CLEAN and Shakti Foundation are good platforms for knowledge creation and transfer, they are much less a platform for true innovation to take place. While Shakti Foundation is not the organisation that will want to be such a facilitator, CLEAN could potentially take up this role to increase the cooperation on innovation within the system. However, another organisation is presenting itself as an important innovation facilitator, namely Smart Power India (SPI). Powered by Rockefeller Foundation, SPI has started a programme to power a thousand villages and acknowledges ESCOs as the key enablers in this. SPI acts like a sort of incubator for six ESCOs, of which Vayam and DESI Power are a part.

In Table D.7 of the Appendix the individual contributions of relations from participants to the Innovation Space are presented. Some findings can be done. Ironically, the intrinsic innovators Mlinda and Gram Power, as seen from the ex-ante characteristics on innovation motivation, are not innovating responsibly according to the data. While their internal innovation might be thriving, the responsible part begins with inclusion of stakeholders, which requires improvement in their case. SELCO also looks poorly connected, but remember that its innovation wing was transferred to SELCO Foundation, which was not researched as a separate entity. Lastly Mrida, Mera Goa Power and Claro appear to leave gaps in an inclusive innovation strategy if they would want to ensure a responsible process. This gap could be closed by strong intermediaries, however, of the ones researched, none has truly innovating relations. IP, GPU and GIPUs are the most connected, but most other intermediaries are little or not visible in the innovation space.

From this data is can easily be seen that Vayam and DESI, but also Rural Spark, Gram Oorja and ONergy seem to have their direct innovation environment in relative order, including most institutions. However, ONergy is the only one who is directly innovating with a government party, showing the enormous gap that needs to be breached towards responsible innovation from the government side. DESI Power as one of the oldest ESCOs, seen from the ex-ante characteristics on firm age, shows that

it is possible to remain active in the field for many years with only a few strong connections to different institutions where innovation happens.

7.2.4. D - Responsible Innovation - The Consensus Space

Where part C of Questionnaire Y mainly exposed the dimension of inclusion, part D finds the other Responsible Innovation dimensions of anticipation, reflexivity and responsiveness. Both the internal processes and the activities with partners are assessed on their responsibility, meaning the presence of those dimensions within the boundaries of the organisation as well as crossing those boundaries. Whenever those dimensions could be found in internal en boundary crossing activities of organisations, their relations are said to be contributing to the Consensus Space. In Table 7.8 the results are presented. A contribution to the Consensus Space is only reached when all dimensions are found internally in organisation as well as in activities with their partners. Partly contribution to the Consensus Space means that some partnerships are responsible, but not all, and is triggered when one or more of the dimensions has 'some' contribution with partners. No contribution to the Consensus Space is when one or more of the dimensions is not shared with partners, even when they are internally visible, since consensus could never be reached on all fronts, as is the case for Gram Power, for example.

Table 7.8: Present RI dimensions in organisations and in relations with partners

Organisation	Anticipate intern.	with partners	Reflect intern.	with partners	Respond intern.	with partners	**Consensus Space?**
Gram Oorja	Yes	Some	No	No	No	No	**No**
Gram Power	Yes	No	Yes	No	Yes	Some	**No**
Mera Goa	No	No	Yes	No	Yes	Some	**No**
Mlinda	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**
ONergy	Yes	No	?	?	Yes	Yes	**No**
Piconergy	No	No	Yes	Some	No	No	**No**
Rural Spark	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**
SELCO	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**
Simpa	Yes	Some	Yes	Yes	Yes	Some	**Partly**
Vayam	No	No	No	No	Yes	Some	**No**
Mrida	No	No	Yes	Some	No	No	**No**
CLEAN	Yes	Yes	Some	Some	Yes	Yes	**Partly**
J-Pal	No	No	Yes	No	Yes	No	**No**
TERI	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**

Internal RI within the participants is the first step towards a responsible innovation system. Anticipation is the dimension that is least focused on by the actors in the system. Five of them are not applying structured processes to discover potential future situations. Four organisations are not reflecting on their own roles and operations. Only 3 organisations have not shown that they posses the means to a responsive behaviour. All together the majority of internal processes seem to happen in a responsible way, however some dimensions could be significantly improved.

However, also a more systemic approach to RI is asked. TERI, CLEAN, SELCO, Mlinda and Rural Spark have all specifically mentioned to be open-source organisations that share all their lessons with others, so that impact can be maximised. So therefore, whenever there is anticipation, reflexivity and responsiveness, it is shared with their partners. Simpa also has its organisation processes built in fairly responsible ways. For the other interviewees, sharing lessons and practises is more difficult, since the boundaries of their organisations remain more closed. This can be reasoned with the thought of intellectual property in mind. None of those actors were found to be considering an intellectual property framework for collaborations and kept their knowledge internal. It appears there are no direct incentives for them to come together and share knowledge. Many of the actors have stated that they often know the other organisations in the field by name, but are not really aware of what they are doing. Whenever such a intellectual property framework would be present, that is adjusted for an

open knowledge environment, openness in the system might increase. Most organisations, therefore, do not currently contribute to the Consensus Space and also not contribute to a degree of responsibility in the system.

In Figure 7.6 the Consensus Space is visualised, where the blue lines signify 'responsible' relations. **The degree of RI in collaborations of the system appears to be at least 33% of total relations or more specifically close to 50% for all researched relations**. This is all done by contributions of SELCO, Mlinda, Rural Spark, Simpa and CLEAN's circumventing relations of founding partners. Because 40% of the visible relations in the map were not assessed on their responsibility, the number on total relations could increase with further investigations, which shall be taken along towards the recommendations.

Taking the number of 50% along, it shows that in the construction phase of the collective innovation process about half of the collaborations are founded on irresponsible fundamentals. Decision processes are not taking into account all the goals, values and requirements of the surrounding innovation system. The implications of this observation cannot be completely overseen, but it poses a risk nonetheless.

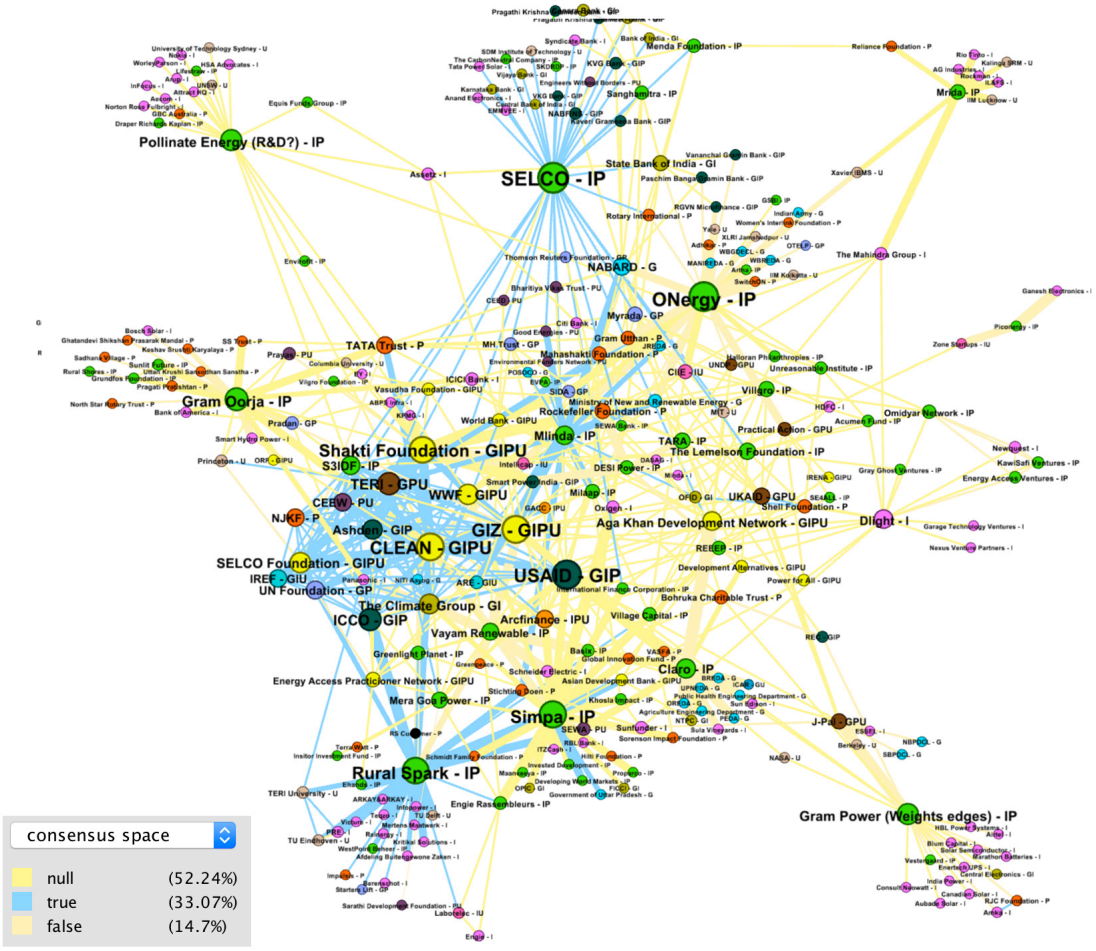


Figure 7.6: The Consensus Space; in blue 'responsible relations'; in yellow relations that could not be determined responsible

Some space in this section is appointed to describe CLEAN as the most important actor in terms of responsibility, due to its centrality combined with the number of responsible relations that surround it. It can be recalled that CLEAN was formed in 2014 from a consensus of several organisations, like Shakti Foundation, TERI, UN Foundation and SELCO Foundation, all surrounding CLEAN in the map in Figure 7.6. The four dimensions of RI were found in this process, where a clear description of the

activities that CLEAN had to fulfill was done, as CEO of CLEAN Hari Natarajan, explained during the interview: *"The idea where CLEAN came from was an extensive discussion of the partners of what the role of CLEAN would be as an entity."* Each institution was represented in those partners, resulting in CLEAN being a GIPU, aligning the goals, targets and values of all institutions and contributing to inclusion. Roadmaps are being made by CLEAN and new human capital is attracted to meet future demands, contributing to anticipation and responsiveness. CLEAN is a young organisation and it is time for some internal reflexivity on the past 3 years, however this process still has to be started, making the reflexivity dimension the only one that needs improvement. To emphasise the importance of CLEAN in the system the situation in 2013 is sketched, just before CLEAN was operational. Figure D.6 in the Appendix gives this representation of 2013 by filtering out connections that were made after that year (or those of which the data was not provided).

There lies an important job for CLEAN as a knowledge network. Because of its centrality and activities in knowledge diffusion it should persuade the rest of the system to open up their boundaries and start including all actors more severely in their anticipation, reflexivity and response activities. CLEAN needs to try to convince them that sharing information does not necessarily mean hurting your own advantages in the market, but can also help to ensure a more stable environment. At the moment CLEAN is mostly sending emails to its members with information about the ecosystem. For example, a recent email to its members calls for comments on the latest draft policy of the National Energy Policy from the Niti Aayog. However, it is questionable if this is enough, since ESCO need to respond within a week, while taking the time to read through more than a 100 pages of new policy. Also the general response on email in India does not promise a lot of feedback from members, as Hari Natarajan confirmed was indeed not the case. It appears that CLEAN needs to find new ways in obtaining knowledge and feedback from its members, since the current processes do not suffice. CLEAN should create the arenas where actors can come together, share lessons and build towards a more responsible future, but more on that in the recommendations of this research.

7.2.5. Discussion and Conclusion on Questionnaire Y

Questionnaire Y was used to generate meaningful insights regarding actors in the system, how they relate and if this is a responsible set of dynamics while operating in the construction phase of the collective innovation process. There has been a lot of information, that might not be easily digested. Data was obtained from a total of 17 participants, of which the majority is directly innovating and constructing solutions for the rural energy sector. 13 participants are IP actors, 2 are GPU actors and 2 are GIPU actors. However, not every part of the questionnaire had the same response. While this section appeared to have little resemblance with the structure of the framework, the elements are hidden within the parts of the questionnaire. This discussion will go back to the structure of components, relations and functions, as was described in the Responsible Innovation Systems framework.

Construction Phase - Components

So from which components does the system appear to exist? A total of 277 organisations were found, of which 60% is part of the industry and civil society sphere or a combination of these two. Government and Academia each consist of 7% of the system. The remaining 33% all consists of intermediaries, of which the majority is a GIPU actor, presumably being fully inclusive in their activities. It must be said that no optimal configuration of innovation system was found to compare these percentages with.

As an example, of the 277 organisations only 2 are Indian technical universities. From Chapter 5 it was seen that a great many of technical institutes exist, so the problem is mainly that they are not included, not that they are not there. Similarly, in that chapter it was found that for every state an SNA and SERC exists. The participants are operational in at least 23 of the 28 states and, therefore, a combined number of 46 SNAs and SERCs might be expected. However, as Chapter 5 also predicted a potential large distance of government from activities on the ground, only 6 SNAs can be discovered in the system and are often only connected to one or two participants.

Because many participants do not connect to G or U, the system appears not inclusive enough. However, the large share of I and P in the system could also be expected due to the majority of participants acting in these spheres, creating a bias. To balance this, the four intermediaries were also

questioned, because these should act as bridges in knowledge transfer between spheres. It might have been expected that more connection to G and U was found with the those intermediaries, however, they also appeared to be poorly connected to the G and U spheres. This shows that the absence of them in the system is perhaps not only due to bias of the participants. Now what does this lack of inclusion mean for knowledge transfer?

Construction Phase - Relations

The 277 nodes were found to have a total of 648 interconnections, of which 309 were directly researched. Those are the partnerships that the participants have made for their construction phase of the collective innovation process. This part of the framework is guided by Open Innovation influences. However, the responses to the questionnaire failed to distinguish between inbound and outbound knowledge flows. Only CLEAN managed to address this correctly, immediately leading to an interesting observation for the most central actor in the system. Other observations are drawn from the availability of different types of knowledge.

During the interview with CLEAN, it became clear that the organisation has a large outbound knowledge, but has difficulties to get inbound knowledge flow going from the members in their network. Often, CLEAN sends out emails with requests for comments on new policy or information about tenders, but they find that the response is little. This can be reasoned, since the most recent requested policy comments required members to read a 106 page document in a few days and write comments on it. Obviously, this is not sufficient time to consider the new policy properly and to discuss with all partners on its implications for their partnerships, preventing proper alignment of future visions.

From Open Innovation literature, it was found that organisations with a central position in the system, high outbound and low inbound knowledge flows operate sub optimal and ineffective. It can be advised to CLEAN to increase the inbound knowledge flows through the boundaries of their organisation, because otherwise their intentions of serving the system will probably not succeed. New techniques should be tried instead of emails with requests, perhaps co-working meetings during fixed time slots throughout the year.

For discussion on the remaining knowledge flows through the system, no distinction between inbound and outbound knowledge flow was determined, leaving only room to discuss absent relations. It might be clear that due to the limited connection to government and academia, political and human capital is not properly diffused through the system, especially because the researched intermediaries also did not properly connect to traditional institutional actors of those spheres. Section 3.2.3 showed that working together with Indian universities showed no economic performance for firms. (Kafouros and Forsans, 2012) This might be an explanation for the little apparent Indian (technical) universities and also puts the blame in the academic institution itself. The government can be seen to cluster around certain firms, which does not create an even playing field. This is especially relevant since the actors that do have government connections tremendously outperform the ones that do not. The talk in the sector is that one can only connect to government if one has friends there. The government has refused every attempt to participate in the research, keeping their operations from being transparent and open. Additionally, resulting from insights in the Knowledge Space, there seems a lack of explicit social capital diffusion from the civil society sphere, because only a few of those actors are performing R&D.

Construction Phase - Functions

The function of responsibly creating, diffusing and using knowledge as articulated in the Knowledge, Innovation and Consensus Spaces was visualised by determining for each relation to which of the spaces it contributed. A contribution to the Consensus Space was defined as a relation that contained elements of anticipation, reflexivity and responsiveness, excepting inclusion since this dimension was already covered by the other elements of the framework.

The Knowledge Space seems relatively well formed with almost 33% of all researched relations contributing to it, because 50% of all actors are performing R&D. When looking at the individual actors, however, both government and civil society appear to be lacking in (explicit) knowledge creation. The most knowledge intensive configurations are IP, GIPU, I and U, showing that despite the few academia

actors, the ones that are present still contribute sufficiently to knowledge production. Between the participants, these numbers vary as well, but not a single one is not contributing.

The Innovation Space is far less filled with only 9% of total relations and 15% of the researched relations contributing to it. The actor configurations of IP, GIPU, I, U and GPU are the only ones of significance in the Innovation Space. The rest of the actor types are hardly contributing to true knowledge combination resulting in innovation. Government, with only a single innovating relation in G and not even a single one in GU and GIU, is the worst innovator of all. Of the participants there are two that do not contribute to the Innovation Space.

The Consensus Space contribution could only be determined for the direct participants. Most participants show structural signs of anticipation, reflexivity and responsiveness, however, very little of them share these dimensions in the relations they have. It means that the dimensions are not aligned among partners and a collaborative consensus can not be reached. However, some participants (CLEAN, TERI, Mlinda, Rural Spark, SELCO and Simpa) do share anticipation, reflexivity and responsiveness with their partners, making them contribute to the Consensus Space. This means a degree of RI in collaborations could be determined, where about 50% of all directly researched relations, was found to incorporate all dimensions and therefore contribute. The main contribution is the consensus forming among important actors in the system that resulted in CLEAN being created. The reason for the number not being higher is a rather closed environment that many participants are having. It is envisioned that CLEAN should take the initiative of trying to open up those boundaries, so that the dimensions of RI can be mutually shared between the actors in the innovation system and make the system behave responsibly in the construction phase of the collective innovation process. Now, however, it must be evaluated whether responsibility can also be found in the implementation phase of the innovation process.

7.3. Questionnaire X - Implementation Phase

A total of five field visits were done in rural areas of Uttar Pradesh and Bihar, of which the exact locations can be seen on Figure 6.2. With the help of a semi-structured approach, the conversation with the end users of rural energy technology was engaged in different settings. Home owners, shop owners, village entrepreneurs, farmers and village communities have been subjected to roughly the same set of topics to understand how they were included in the process and how this has increased their capacities to anticipate to the future, reflect on their own roles and respond to all kinds of situations. With the help of Shahzeb Yamin as an interpreter and guide, a dive was done into the implications that decisions on energy development really have.

7.3.1. Gram Power, Bodhgaya, Bihar

With a look at the nearby temple where Buddha came to enlightenment, a little shop was entered in Bodhgaya. In no time there was a baked clay cup of chai at hand, the local combination of sugar, milk and tea in that order, which is used to spring conversation in India. In the street, adjacent to the local police station, little shops are situated that are connected to the electrical grid of a private DISCOM. Several months ago, every shop in that street was made part of a cluster of smart meters developed by Gram Power, of whom Kalicharan Saw accompanied the visit. The remaining clusters in the area made the total amount of customers in the neighbourhood around 120. Under an electric fan, against the pushing heat, the conversation with the shop owner began.

The smart meters were installed without much consent of the users, that much became clear at an instant. Without informing the shop owner, the DISCOM had placed a meter in his shop. Only once in a while there was a government official coming by to check and researchers from the university of California promised to come by, but never came. When the shop owner was asked how he felt about the new smart meter Gram Power provided, he answered with: 'The new smart meter is good'. When asked 'why?', he explained: 'It just feels good'. There seemed, maybe understandably, little understanding of what the meter was doing, but at least it gave him no reason to be unhappy. In the mean time, another shop owner of next door came in. He joined the conversation and stated that the flexibility of the DISCOM in billing issues had increased since the instalment of the smart meter, which made him happy. Gram Power further increased his satisfaction by promising to pay for the interest

Figure 7.7: The shop owner with his most energy intensive device, a fridge

on his open bill with the DISCOM and was handling maintenance much faster then before, whenever some wire broke down.

This shows that regardless of their understanding of what is going on, Gram Power and India Power managed to satisfy the end users by providing services around payments and maintenance. This important insight of a simple reason for customer satisfaction should be an important lesson for others. However, the little understanding of the product could become a problem when the area of Bodhgaya develops, because the end users do not understand the full potential of the options they have. The possibility of a solar panel on the roof was never considered, while the shop owner's open bill with the DISCOM of 35,000 rupee (500 euro) allows for the purchase of multiple solar panels. What happens when he starts requiring more products and a better energy management in his shop that also served as a hotel? The growing stream of tourists could be a welcome new income. The shop owner is hampered in his own potential of expanding his energy system, because of a lack of knowledge.

With real-time data coming from the smart meter, the accompanying employee of Gram Power showed the current energy use of the shop owner on his smart phone. Data that the shop owner did not even know was possible to visualise, since he had no smart phone. In this particular case, the smart meter seems to be more beneficial for the utility than for the end user. Although, it can be argued, looking at the bad state most utilities are in, that this is also in the customer's interest. Upon asking the shop owners if they would like to be included more, they answered affirmative and willing to spend more effort in understanding their product. Although, they also felt the current situation was already good enough, which made me question if they would really put time in such a complex task.

7.3.2. Vayam Renewable, Buknari, Bihar

With an irritated cab driver, who's Tata Indigo vehicle was not made for off-road terrain, the car moved slowly over the humps and bumps on the path leading to Buknari. Some time ago, one of the villagers who served in the army was killed in an attack near the border of Pakistan. The day before the funeral, the road was suddenly improved overnight to be able to transport the military and government officials who attended, however, little could now be seen of that. The village contains about 200 households, of which 43 are connected to the solar microgrid of Vayam Renewable, installed 1.5 years ago.

While waiting for Sunil Mahto from Vayam, who would accompany the visit, there was an ability to talk with some people who were not connected to the microgrid. Whenever a household could not make the down payment that was necessary up front, they were not included in the design of the microgrid system. However, they do have access to energy. They are stealing electricity from the government grid walking right through the village, installed 5 months after the Vayam microgrid, as

can be seen in Figure 7.8. The government did not provide any official connections to the villagers, so they just took it. This can create unforeseen imbalances in the grid, contributing to the many power outages that the whole of India experiences. The villagers stated that they were very much willing to pay for legal connection, if the government would supply the necessary equipment in the form of meters. As long as that does not happen, they would keep on stealing, they said.

Figure 7.8: Illegal connections to the central government grid

As soon as Sunil arrived, the part of the village was visited that had the microgrid installation. Surrounded by dozens of interested children, the installation was discussed and the knowledge and pride the community felt for their system became apparent and their inclusion in the project was evident. The reason that this project showed the most signs of a structural inclusion of the customers, might be because the village took the initiative themselves, ensuring their own involvement. They have been included in the preceding design process, are frequently evaluated and are informed of possible future adjustments to the system. Vayam is now looking for the possibility of installing a running water system with pumps powered by the grid, on the request of the villagers themselves. All this is coordinated with the community, represented by a single villager, who has taken the role of spokesperson, small maintenance and billing. The villagers are very satisfied by this and even want to be included more. Once even an NGO came by, however no researchers were ever seen before. They are eager to know which future activities are going to take place, so that perhaps more people in the village can be connected. The positive attitude to their inclusion has made them grateful and self relying. Despite promises of local officials, no immediate need exists for them to connect to the local government grid that runs through the village. Because of the irrigation of the land, they can now harvest more crops and sell more goods, making them more wealthy as a community. All dimensions of Responsible Innovation were found to be present in the activities and attitudes of the Buknari community, since anticipation on the running water system is happening, reflection of the role division between Vayam and the community, inclusion because of their participation in improving and maintaining the system and responsiveness because of their increased resources on agriculture and increased knowledge of electricity systems.

7.3.3. Rural Spark, Bankey Bazar, Bihar

In the South of Bihar, close to the border of Jharkhand, Bankey Bazar is situated. Rural Spark is working here with an interesting product. Their idea is based on the concept of creating bottom-up energy networks through energy sharing principles. They sell an energy kit, containing a solar panel

connected to an energy router with a battery pack and a set of 12 lamps with internal batteries. The interesting part is that these lamps can be rented out to other villagers, therefore allowing a new business model to emerge and the villager to become a Local Energy Supplier (LES).

The interview was done with Rina and Rita, two Bihari women that have been LESs since 4 years. They have been renting lamps to people and have been earning some significant extra income that helped to pay for the education of their children. They have truly become business women and increased their status in the village, maintaining customer relations and creating a stronger social network for themselves and the village. Figure 7.10 shows the empowerment they have gotten, because they do not look down or away, covering their faces. They are confident enough to look a strange foreign man directly in the eye, something they did not do before, according to Shahzeb.

Figure 7.9: In conversation with Rina and Rita, two empowered Indian business women, generating income through selling energy

While in the design of the initial product, they had little influence, in the iterations that have come in the years, much of Rina and Rita's feedback has been taken into account. However, some of the feedback seems not to be included, such as the feedback on battery life and lamps brightness and shape. These are crucial factors for success and therefore they are unsatisfied that their voices are not taken into account on that yet. It would be a suggestion for Rural Spark to create a better customer/LES feedback system. Still, they are happy with the promises of Rural Spark to add fans and television to the products that are able to run on the system they provide. Furthermore, there have been many visits of researchers from Basix, but no government official has ever come to talk to them.

Some interesting things can be noted. Upon arrival of the central governmental grid, the use of the Rural Spark product went down. However, after some weeks, when people had experienced that the grid was still not a reliable source of electricity, the renting of lamps started to go up again. A bottom-up approach was now co-existing next to a top-down grid. Another interesting dynamic was seen, when an alcohol ban was set in place, prohibiting the sales of alcohol throughout the whole state of Bihar, after a strong women rights groups lobby. Since the ban, the revenue that LESs receive has gone up. Presumably this is because the man of the house is not spending the money on alcohol anymore, but on an energy supply for his family. It shows one of the important social problems that the Bihari people have been facing in their path on development. Finally, the initial inclusion of Rina and Rita in the design process was the source for their further involvement to anticipate on new product, reflect on what was being done with their feedback and respond by giving critique. Less inclusion in a later stage discouraged the other Responsible Innovation dimensions as well. Could inclusion be the gateway dimension that drives the others?

7.3.4. Simpa / Rural Spark, Badaun, Uttar Pradesh

A collaborative pilot project between Simpa Networks and Rural Spark was visited in the district of Badaun, Uttar Pradesh. Simpa has positioned itself as the distribution partner in this collaboration, delivering the services to the end-customer. They work with local sales and service agents, who act as the spokesperson. The customer service system is very sophisticated with a customer care number available for the customer, which can be used to report a problem, with a turn around time of 72 hours. The location of the Simpa agents is tracked, to be able to quickly respond to situations happening anywhere in the area by sending the nearest agent. Also the warehouses are close by for short distribution times. Rural Spark delivered the same product as described before in this collaboration, but leaves the services and billing to Simpa now. The project is still in the pilot phase, where this visit together with Rural Spark was meant to finalise instalment of the product. The instalment was done in front of the family and the youngest one showed immense interest in all the parts of the products. The knowledge that is needed for energy products to sustain in these villages could be directly transferred by the sales agents of Simpa and Rural Spark, instead of the long distanced government officials that place poles and lines.

Figure 7.10: A young child discovering energy products

Again with the help of some chai, the conversation started flowing. It was found that the village was the only one in the area that did not have a governmental grid yet and the only reason for it was that the whole village voted for the losing party in previous election. As a form of revenge, the winning party decided that the village was not to be electrified. However, after the recent election in Uttar Pradesh, the village has regained faith in the government electrifying the village, since they have been supporting the party that won. It shows the uncertainty around development projects and the unfair and corrupt role the government plays in this, pressuring villagers for votes. Rather than a supporting role, the government has played a depressing role in the electricity story of this village. The lack of inclusion by the government has resulted in a more entrepreneurial attitude, where most of the rooftops in the village contained solar panels. Yet the villagers were hopeful and already knew what they wanted when more electricity was available: Fans and water pumps for irrigation. Even though the inclusion was only in the starting phase, anticipation of the future was already sparked. More knowledge about the energy products should eventually spark reflexivity and responsiveness too, however, now these were not discovered at present.

7.3.5. Claro Energy, Daulatpur, Bihar

The last project that was visited was from Claro Energy, who installs solar powered irrigation systems for farmers. Only after finding out that there were multiple villages called Daulatpur in Bihar, the realisation of being in the wrong place came. Keeping spirits up and hopping back into the car to reach for the 'other' Daulatpur. The land of a local farmer was entered, where five years before a solar irrigation installation was placed, visible in 7.11. It waters several farms in the community. At that time the decisions were made under the reign of his father and until now everyone in the farming community was very satisfied, since the installation had never broken down and delivered a lot of benefits.

The process of installation was similar to the Vayam Renewable microgrid. However it differed in the set of actors that were included. The irrigation department of the Bihar Government, where his father had a contact, had introduced the farmers to Claro. However, before Claro came in the picture, all the characteristics of the project were discussed between the farmers of the area and the Irrigation Department, creating a consensus of the stakeholders, with the governmental party as the middle man. Only when consensus was achieved, Claro came in and installed the solar irrigation plant according to the specifics discussed. The farmer with the contact in the government department was designated to maintain the installation and do the necessary billing for all the farmers that made use of the irrigation. In return he is paid by Claro for his activities.

The contract with Claro, however, was made for 5 years. At the time of our visit, his last month had gone in, but there was no clarity for the farmer what the next month would look like, since there were no ongoing negotiations about a new contract. The farmer hoped that he would be assigned under the jurisdiction of the Irrigation Department, but how he came to think that was unclear. Mukund, the Claro Energy employee accompanying the visit, said on the way back that Claro would most likely extend the contract, something he did not tell the farmer moments before. It poses as a suggestion to Claro, to better inform the farmer about the things that are going on, since there also seemed little knowledge about any future products or services that Claro is designing at the moment. It would seem that the initial inclusion of the project laid grounds for a succesful project, but the current lack of inclusion might be the reason for a very limited anticipation, reflexivity and responsiveness of the farmer.

Figure 7.11: Three of the six solar panels used power to the pump that irrigates the land, but powering nothing else

Another interesting thing to see was how little connection the farmer felt to Claro as a brand or as a company. He was, after five years of receiving significant benefits, capable of setting aside Claro

without a thought. There appeared to be little 'connection' to Claro and he saw Claro mainly as a source of income, nothing more. It raises questions on what Indian rural energy technology companies must do to form a relation with their customers, if even this kind of effort is not enough to bind a strong relationship.

Another interesting finding was done when the question was raised what happened with the generated energy of the solar panels, when no irrigation was done. The farmer did not seem aware of this and would not know what it means that there is extra energy. If this is the case for more farmers, much more energy could be used to serve the rural customers with other services than irrigation, simply by educating them about what are the possibilities and allowing them to share the energy. This observation is at the foundation of the Energy Bazaar project, a new organisation aiming to increase energy access, democratise energy ownership and maintain sustainable innovation. The concept of Energy Bazaar is fully explained in Appendix H

7.3.6. Discussion on Field Visits

So what lessons can be drawn from these visits? A focus was put on the components present during the process, if there are knowledge flows visible and if the rural population anticipates on the future, how they reflect on their own role, if they experience inclusion in the project and how they respond to changing situations. Again, the structure of components, relations and functions as found in the framework shall guide this discussion on the data collection of the implementation phase of the collective innovation process.

Implementation phase - Components

Since the implementation phase is somewhat different, the components are not described in the sense that U means that a university is present, but rather that human capital is created. Meaning, are the end users educated by the project in some way? Similarly with the other institutions of the Quadruple Helix. The presence of government can still be considered, as that of the industry partner, being the social enterprise delivering the product. Table 7.9 shows the overview of the observation of these components.

Table 7.9: Components of institutions found during the field visits

Organisation, location	Technology	G	I	P	U
Gram Power, Bodhgaya	Smart meters	Some	Yes	No	No
Vayam, Buknari	Microgrid	No	Yes	Yes	No
Rural Spark, Bankey Bazar	SHS	No	Yes	Yes	Yes
Simpla / Rural Spark, Badaun	SHS	No	Yes	Yes	Yes
Claro, Daulatpur	Solar irrigation	Yes	Yes	Yes	No

The show owner in Bodhgaya only had contact with Gram Power and the DISCOM. Once in a while a government official came by, but it was unclear what this person did exactly. There was no customer group looking after the interests of all the smart meter owners in the street, no village energy committee or NGO. Also no human capital was created, or capacity building was being done, because he was not learning anything new from this product or research was being performed on him.

The microgrid in Buknari had involvement of Vayam and together they created a strong village level committee that represented the customers in the village, arranged payment collection, small maintenance issues and discussed future changes and upgrades to the product. Government was not involved, since the microgrid customers had no need for that, despite government officials getting involved by persuading them to connect to the government grid too. While certainly villagers learned new skills, such as a more diverse crop harvest, this was more of an unforeseen benefit than that it was really intentional capacity building. Also no research was being done on them by any university. The village could benefit from an even more robust project by focusing more on capacity building and education.

Rural Spark's product in Banky Bazar has these human capacity building components structurally embedded in their product, due the the creation of village level entrepreneurs, who manage their own customers and see to their interests by communicating to Rural Spark in case of problems. Also,

they are working closely together with research projects and universities that come by in the villages. This is making them the only participants of the field visits that contribute to the U sphere in the implementation phase of the innovation process. At the same time economic capital is created due to the creation of local business models. However, there is not a single contact with government, still not reaching full inclusiveness in the implementation phase. The same goes for the collaboration with Simpa in Badaun.

Lastly, the farms in Daulatpur are the only ones who have experienced structural government inclusion, through involvement of the irrigation department. There has been a strong initial GIP collaboration, due to a cooperation of farmers in the area that looked after their own interest in the implementation process of the project. It must be noted that this strong cooperative process was not fully recognisable anymore at the nearing end of the contractual term. However, despite the farmers being satisfied, after five years no signs of capacity building or any education regarding energy was noticed. All the farmer had basically learned was to switch the installation on and off and therefore he did not have the capacity or empowerment to involve himself regarding decisions for after the contractual period has ended and waited helplessly for others.

The components element of the framework shows that there is not a single project that can be considered fully inclusive throughout the implementation phase. While full inclusiveness is not directly related to customer satisfaction, it does help in sustaining projects. It can be concluded that not sufficient political and human capital is created to ensure a sustainable implementation process. Still, the advances that have been made by most of the projects on social capital is impressive and comforting in ways.

One of the participants of Questionnaire Y who offered a field visit, but due to logistic barriers was not visited, did a very extensive description of its activities that has led to believes of being a fully inclusive project. Mrida, meaning 'soil' in Sanskrit, is operating with a model that includes all institutions and aims to create local economies, literally being the soil for a sustainable development to grow on. Their case would be an interesting one to research with the Responsible Innovation Systems framework and is therefore taken along to the recommendations.

Implementation phase - Relations

The relation element of the framework, governed by Open Innovation, looks at the knowledge flows going through the boundaries of the project. It might be clear, that end users do not perform R&D like the organisation of Questionnaire Y. Therefore, a slightly different perspective on knowledge flows needs to be taken. Some things might be discovered in a light of communication between the parties, which effectively is also knowledge transfer. Knowledge transfer will therefore be considered here as a communication channel with substantial information that could lead to new types of practices or insights. Also, two-way communication channels will ultimately allow for the Consensus Space to emerge between the end users and the product developers, since anticipation, reflexivity and responsiveness can only come through exchange of information. Table 7.10 shows the results of the observations on in- and outbound communication channels.

While the shop owner in Bodhgaya only communicates to Gram Power about money and nothing of that personal communication contains information about the potential of the smart meter he is having in its house, there still is a outbound communication channel that the shop owner was not even aware of. Through the smart meter, Gram Power and the DISCOM have a full insight in the usage patterns of the show owner, providing them with valuable data that can be used for many things. It would serve

Table 7.10: Direction of communication channels in rural projects

Organisation	Technology	Inbound	Outbound
Gram Power, Bodhgaya	Smart meters	No	Yes
Vayam, Buknari	Microgrid	Yes	Yes
Rural Spark, Bankey Bazar	SHS	Yes	Yes
Simpla / Rural Spark, Badaun	SHS	n/a	n/a
Claro, Daulatpur	Solar irrigation	Yes	Yes

the project if Gram Power would be able to open up this channel of information to the customer itself, that did not possess the knowledge of this possibility or the means, such as a smart phone, to do this.

The microgrid in Buknari benefits from a clear two-way channel of communication, facilitated by one community member doing all contact with Vayam. He articulates the comments and demands of the community, while returning information provided from Vayam. Because of this, the community managed to communicate their wishes for upgrading the system with a running water network, powered by the sun, while also getting the response that this was possible.

The village level entrepreneurs in Banky Bazar, have specifically been part of the design process. Their comments have been partly taken into account during the iteration process of new products and is therefore a clear example of open innovation with end user inclusion. For the collaboration with Simpa this is also expected, however, the project was in an too early stage to say something about that. Also Rural Spark operates an online platform where information about the sales of all entrepreneurs is collected.

Finally, the farmers in Daulatput were also extensively included during the initial phase of the project, communicating their demands and receiving the requirements from the irrigation department and Claro in return. This has led the project to be successful for five years. However, currently the communication channels seemed to have closed up and uncertainty about the continuity of the project exists.

Implementation phase - Functions

So how are the project contributing to the functions of the framework, meaning *the Knowledge, Innovation and Consensus Spaces*? Again, the conceptualisation seems off target with rural customers, but also here some comments can be given. It is important to see a contribution to either of the spaces from the project with end users itself. A great deal of innovation might have gone in a certain product, but if innovation stops after implementation, there is no contribution to the Innovation Space anymore, for example. Table 7.11 gives an overview of each project and its contributions to the Knowledge and Innovation Space.

Table 7.11: Contribution the Knowledge and Innovation Spaces

Organisation	Technology	Knowledge Space	Innovation Space
Gram Power, Bodhgaya	Smart meters	Yes	No
Vayam, Buknari	Microgrid	No	Yes
Rural Spark, Bankey Bazar	SHS	Yes	Yes
Simpla / Rural Spark, Badaun	SHS	n/a	n/a
Claro, Daulatpur	Solar irrigation	No	No

The Knowledge Space is only addressed by Gram Power and Rural Spark, because of their data collection which can be used for analysis of usage patterns and provide insights that otherwise would have stayed hidden. Rural Spark and Vayam also contributed to the **Innovation space**. Rural Spark since the village levels entrepreneurs are included in the design process, while they can also set their own prices and business models, therefore innovating themselves and their energy businesses on the base of best practices. Furthermore, the community microgrid of Vayam contributes to the Innovation Space, since the community has been empowered by the means provided through Vayam to combine their existing knowledge with the current product and therefore improve and upgrade it, resulting in a future upgrade with a running water system powered by solar panels.

The Consensus Space, finally, reveals if the dimensions of responsibility are discovered in the activities of the projects. A focus was put on if the rural population anticipates on the future, how they reflect on their own role, if they experience inclusion in the project and that of other institutions and how they respond to changing situations. Table 7.12 shows how the dimensions are found in each field visit.

Anticipation regarding future development in the product was only truly found with Vayam and Rural

Table 7.12: Discovered RI dimensions during field visits

Organisation	Technology	Anticipation	Reflexivity	Inclusion	Responsiveness
Gram Power, Bodhgaya	*Smart meters*	No	No	No	No
Vayam, Buknari	*Microgrid*	Yes	Yes	Some	Yes
Rural Spark, Bankey Bazar	*SHS*	Yes	Yes	Some	Some
Simpla / Rural Spark, Badaun	*SHS*	Some	No	Some	No
Claro, Daulatpur	*Solar irrigation*	Some	Some	Some	No

Spark. Both projects showed signs of end users expecting new iterations of the product and future developments. In the case of Claro there were a lot of uncertainties about the terminating contract this month, however, no solutions to extension or replacement of the contract were being envisioned, except for the farmer hoping to get a contract with the irrigation department. With Simpa in Badaun, the project was still in an early stage, but the customer did not really know what to expect in the future, except for the need of solar irrigation. With Gram Power there was absolutely no sign of anticipation by the end user.

Reflexivity, again, was only really found with Vayam and Rural Spark. In the microgrid the complete community was organised around operations of the product, was doing collection of monthly payments and doing small maintenance, as was all discussed with Vayam in the division of roles. With Rural Spark the local energy suppliers also had a clear understanding of their entrepreneurial role in the system, where they were the suppliers of energy to the villagers, due to renting of lamps. With the farmer from Claro, the early stages of the project certainly showed clear signs of reflexivity, with a clear division of roles. However during the current final stage of the contract, the farmer had no idea what his role was going to be and if the project could go on. The Simpa case was to early in the project for the customer to already have developed a coherent image of what his role was. Again the shop owner with the smart meter from Gram Power showed very little understanding of what it meant to be the owner of a smart meter, since for him little changed from the point it was installed in his operations.

Inclusion was already seen partly in the components section, where it was determined that not a single project included all four institutions sufficiently. However, some comments on the inclusion of the end users themselves might be given too.

Inclusion does not turn out to be a direct positive influence on customer satisfaction, since the Gram Power shop owner was not included, but was still happy about the product. Both Claro and Rural Spark showed a large inclusion at the start, with a large contribution to the other dimensions as well. However currently the inclusion level in those projects has gone down, and the other dimension decreased too. It hints towards the logical observation that anticipation, reflexivity and responsiveness can only be triggered with initial inclusion. While this seems obvious, it has important implications, since responsibility and sustainability of projects can, therefore, only be reached with inclusion. Today, many projects are not including end users to a high extend, since it costs a significant number of resources to maintain these processes and customer satisfaction, apparently, is not necessarily bound by inclusion. To promote inclusion, these findings show that it is very important to include end users in the light of responsibility and sustainability of the project.

Responsiveness was only to be found with the microgrid, where the end users were actively expanding their village with the wealth that the generation of their own energy was creating. They were diversifying their crops and were pressing Vayam to install a running water system in addition to the microgrid. The local energy suppliers as entrepreneurs with Rural Spark also showed some signs of responsiveness, due to their capacity of keeping renting of lamps going in changing societal circumstances, however their responsiveness had gone down after their inclusion had gone down, due to a lack of integration of their feedback on the product. With the other projects there was no evidence of end users taking specific actions in response to changing situations or to include themselves better in the design process.

7.3.7. Conclusion on field visits for the implementation phase

The last stage of the collective innovation process has been examined by field visits towards rural areas, where energy technology products are implemented. With the help of the Responsible Innovation Systems framework, the elements of *components, the relations and the functions* of the innovation system could be determined.

The **components** element shows the inclusiveness of the projects and to what extend the quadruple helix institutions (or the specific capitals they should create) are present. The results have shown that none of the projects is fully inclusive in that sense. Government inclusion is only truly found in one of the projects and University (or human capital creation) is similarly scarce. This has implications for the responsibility, and ultimately sustainability, of the project, because not sufficient political and human capital is created to create robust solutions for the long term. Still, the civil society sphere is included extensively in projects, with only one of the projects failing to address social capital creation. This shows the inclusion of rural populations is considered to a large extend by current activities. Also, all projects consider the economic capital creation of the Industry sphere, because of the private undertakings of the researched projects.

The **relations** element effectively shows the openness of communication channels, which should allow for two-way knowledge flows. In the case of the field visits, this communication channel was considered open if there was knowledge flow between entities that had the potential to result in new innovation to the projects. It was found that each project contained knowledge flows outward from the boundary of the end users. Examples exist of end users articulating requirements to the design, participating in the iteration of product cycles with feedback and electricity usage data collected through smart meters, showing that the end users are being heard. Inward knowledge flow, meaning information coming from other sources to the end users, is also well established. Only the smart meter owners did not receive any information about their product and could therefore not comprehend what the product could mean for them. The microgrid, solar home systems and solar irrigation projects all had a strong inbound knowledge transfer. The results show that the infrastructure for two-way knowledge flow is available and may result in the mutual transfer of perspectives on anticipation, reflexivity and responsiveness.

The **functions** element is represented by the functional spaces of Knowledge, Innovation and Consensus. Through data collection, two of the projects helped to contribute to the Knowledge Space. The Innovation Space was enhanced by two projects that allowed knowledge combination with end users to lead to new practices. This shows that not all projects are actively contributing to knowledge and innovation. In the Consensus Space, finally, the dimensions of Responsible Innovation are represented. None of the projects has managed to contribute to all dimensions, but a large variety exists. The smart meter owners had least understanding of anticipation, reflexivity, inclusion and responsiveness. The solar irrigation project touched the dimensions in the initial state of the project, but appeared to have lost this in the current state. The SHS users were anticipating and reflecting to a large extend, but not that responsive. Finally, the community microgrid users showed anticipation, reflexivity and responsiveness very clearly.

So what does this mean for responsibility in the implementation phase? The requirement of being inclusive in Quadruple Helix components, having two-way communication channels for knowledge flows and articulating all functions in the form of Knowledge, Innovation and Consensus Spaces is clear. The framework has helped to look critically at the presence of these requirements. It showed that none of the projects appear to meet the requirements, especially due to an insufficient inclusion of all components. The relations element is not a barrier, since most projects have two-way knowledge flows. The functions element also requires some improvement for most, because the Knowledge and Innovation spaces are not subject to contribution by most projects and the Consensus Space leaves some gaps, especially in responsiveness. Therefore, none of the projects can be considered fully responsible. The community microgrid of Vayam appears to be the best performing, because it only misses inclusion of university and government components and a clear contribution to the Knowledge Space. The Rural Spark local energy suppliers project in Bankey Bazar is also close to full responsibility,

because only inclusion of a government component and better responsiveness in the Consensus Space is required. The other projects leave significant gaps whenever the goal is to apply a responsible collective innovation process. The failure of projects to reach full responsibility, however, might also be subject to external influences, urging to consider if the conditions to form a responsible innovation system have been met.

7.4. Discussion on Conditions for a Responsible Innovation System

None of the innovation phases gave strong evidence of a responsible collective innovation process, with severe gaps in several of the requirement to such a process. It should be considered that the reasons for these gaps do not only lie internally in projects, but are also due to external influences, which prevents a responsible innovation system to emerge. In Section 4.2.5 the enabling conditions to the Responsible Innovation were presented. In this section it is discussed whether those conditions can be considered to be sufficiently met, so that the emergence of a responsible innovation system is even possible. Figure 7.12 quickly visualises this with the colours green and red, respectively, meaning if the condition is met or not. A gradient of green and red signifies that the condition is not met, but elements for success can be discovered. It must be disclaimed that this evaluation is done on the potentially subjective and incomplete perspective of the researcher and should be more closely examined to give more valid conclusions on these conditions.

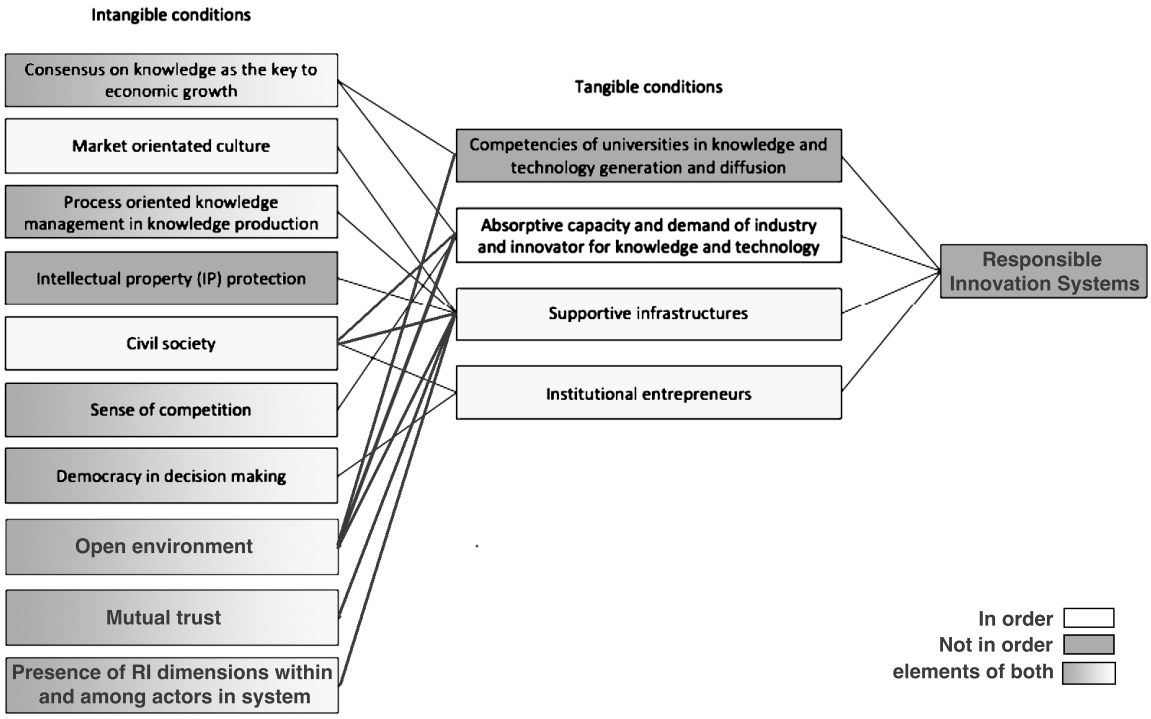


Figure 7.12: Found Status of Conditions for Responsible Innovation Systems

Starting with the intangible conditions. So is there **consensus on knowledge as the driver of economic growth**? All participants of the research have acknowledged to do some form of knowledge creation, through R&D in their organisation or with others. However, there is not yet consensus on the need for combination of this knowledge between institutions, which is a key driver for innovation. That is why this particular condition is not fully covered yet.

A market orientated culture, where institutions can take the role of the other institutions, has certainly been found. Both Shakti, J-Pal and TERI, all core human capital actors, have been shifting their operations to cover weak institutions. Also the large amount of social enterprises shows that industry can also take the role of Civil Society, where some have also resulted from the opposite direction, like ONergy.

Process orientated knowledge management in knowledge production is a bit more difficult

to discover. Certain entities, such as Shakti, TERI and J-PAL have clear processes in their knowledge creation. However in the social enterprises, this competence is less found. Only SELCO has fully operational and structured knowledge creation. ONergy, Rural Spark and Mlinda do have strong emphasis on new knowledge creation, however it does not appear to be as routinised as with SELCO. The other participants show no signs of knowledge management, apart from Simpa in their strong customer feedback operations.

Intellectual property protection was already mentioned many times in the literature section as an important barrier to the emergence of openness and therefore responsibility. Again, for the case of rural India, it is seen that it remains an issue unsolved. Not a single one of the participants mentioned to have any form of intellectual property protection.

In India a strong **civil society** appears to be present. In the network analysis it is the second largest institution, after industry, with many NGOs, customer groups and action groups present in the system trying to make the rural population financially, socially, culturally and politically included. The basis for the Quadruple Helix to emerge in terms of societal actors at least is visible.

A sense of competition, relating to sufficient feedback loops in the system, is more difficult to find. One clear example is the slow, but eventually apparent, privatisation of the energy sector, initialised by the Energy Act in 2003. Figure 5.5 shows that the sector is becoming increasingly private (in terms of generation), therefore showing the feedback that the policy aimed for. Also the electrification programme, even though government communicates false numbers, is really increasing energy access. However, other policy schemes are more difficult to discover, such as the wish to make DISCOMs financially healthy, which they are still not. Furthermore, the other way around, industry feedback on policy is difficult in the rural context. The channels towards government, as the attempt to give feedback on the latest policies, have shown slow or missing, since it got no response. The top-down staircase from government seems too high to climb for some bottom-up initiatives. In that case, government needs to come down the staircase and help create open arenas for discussion.

Democracy in decision making relates to this last observation. While the diversity in institutions could be sufficient, much of the decisions are being made within institutions, without properly consulting other parties. Especially in policy making this barrier is prevalent. Options to give input are there, but the threshold is very high to do so and the chance of being taken into account is very small, as the public hearing of the CERC and the responseless feedback on policy exposed. The other way around, local initiatives are reluctant to include government, because of a lack of trust in the institution. Several intermediaries, however, are trying to close the gaps between institutions and are trying to get selection mechanisms together, so that values of each institution are included in innovations. Still more work is needed.

An **open environment**, where knowledge can freely travel is needed for a responsible innovation system. Several actors are actively trying to create such an open environment, such as CLEAN, SELCO, Rural Spark, Mlinda and TERI, because they aim to be open source and share their lessons. The climate solver event of WWF similarly tried open discussions to evolve. However, most companies do not recognise the need for a knowledge democracy yet. With fear of losing their intellectual property, companies keep their boundaries closed or simply do not comprehend the concept of open knowledge flows. Still, most partner up with other institutions to get knowledge flows going, therefore having at least semi-open boundaries.

Before trust can sustain, integrity needs to be shown. Mera Goa Power experienced a breach of trust, with an early partner that made misuse of a situation. It has resulted in a strong inward mentality of the social enterprise, with only trust in personal contacts in the villages. Even in one of their five company pillars it is mentioned that no third parties would be included. **Mutual trust** among all stakeholders in the system is perhaps the most difficult condition to establish in (rural) India. Some evidence on trust was found in a study on microfinance in rural India. Inter personal contacts account for a high level of trust, however, whenever it considers a national of regional formal institution, the trust level at the community level is severely decreased. (Sriram, 2005) The evidence from this case study on rural energy technology resonates with that finding. The social enterprises such as Mera Goa Power, Mrida, Vayam, Rural Spark and Simpa get their successes from personal relations on the field, where levels of trust are built with local communities. However, on those local levels, a severe mistrust exists towards government at times. Some of the social enterprises have stated that they do not wish to receive government funding/subsidy, because of the negative image that could be created among some communities. Mutual trust is therefore present within local contexts, but not among all

institutions, while this is absolutely necessary in ultimately reaching systemic responsible innovation. However, before that can happen, the integrity of actors needs to be established and known with others.

The presence of RI dimensions within and among actors in the system is also partly met, as was seen in previous section explaining part D of Questionnaire Y. Most RI dimensions can be found within the participants themselves, but they are not frequently shared among their partners, possibly creating diverging sets of goals, expectations and values in the innovations. Therefore, this condition is not yet met.

The tangible conditions can also be discussed. The **competencies of universities in knowledge and technology generation and diffusion** have not showed up, where there are only a few universities visible in the exposed system. Hardly any connections exist between the university sphere and the other institutions and therefore the knowledge diffusion is not optimally happening.

As Scholten and Van Der Duin showed, **absorptive capacity** can be measured. (Scholten and Van der Duin, 2015) For this research this has not been done, therefore this condition is left open. Further research might expose the status of absorptive capacity in the system.

Supportive infrastructures in the form of policies, funding and communication channels have been found extensively. Recent policy is addressing most of the previous gaps in the policy environment, apart from inclusion of recent and experimental technologies that are rapidly being introduced. A diverse and available funding structure exists, laying the ground for projects to be undertaken. Furthermore CLEAN is situating itself as the communication channel of the system, informing organisations in the system of new and relevant policies and initiatives.

Institutional entrepreneurs are prevalent in the industry and civil society institutions, like SELCO or Rockefeller Foundation. Also in the university sphere, TERI can be accounted as highly influencing the development in the system. For government the NABARD has proven itself a boundary crosser, as one of the few. Institutional entrepreneurs are surely present and the possibilities can be exploited. It could be argued that this needs to happen more, but this condition is seen as met.

7.5. Insights on the Applicability of the Framework

While this case study was partly meant to do an assessment of the responsibility of the innovation system of rural energy technology, it was mostly an initial attempt to test the use of the constructed framework. Part of the results of this case study should therefore contain an evaluation of the applicability of the framework as well. It is important to consider if the framework was able to assess systemic responsibility and if it is able to guide towards that, while remembering that responsibility in the collective innovation process was specified as: *"Application of the intertwining dimensions of anticipation, reflexivity, inclusion and responsiveness in an evolutionary environment with actors of an innovation system that contains a constant group of institutions, while an open knowledge environment is present*". Again, the three phases of the collective innovation process are used and each evaluated separately.

In the **exploration phase** it could be determined that there are both responsible and irresponsible events, showing that both success and failure could be determined. Each element of the framework could be assessed in this phase, because the different institutions in the *components element* were found to be either included or not, open and closed environments were determined in the *relations element* and in the *functions element* the dimensions of anticipation, reflexivity and responsiveness were found in some events, but not in others, while knowledge creation, transfer and combination into innovation have all been observed through the framework. It seems, therefore, that the framework is useful for determination of the responsibility of multi-disciplinary events that are held in innovation systems.

In the **construction phase**, the framework was applied on two levels. Firstly, on the perspective of the individual participants, while also a mapping of the system could be done from all the partners of the participants and their interconnecting relations. The *components element* managed to expose

which institutions were not in the partners of the participants, showing which types of capital were not included in their innovation processes, mostly human (university) and political (government) capital. On the level of the overall system, the percentages of institutional configurations could be determined, however this does not directly say anything, since the number of actors does not directly say anything about the inclusion in the collective innovation process, because much more civil society actors exist then university actors. Also, it might be noted that the actors that now fall under the same institutional configuration, might actually be completely different in what kind of activities and functions they perform in the system, making it hard to draw conclusions. In the *relations element*, unfortunately the desired observations could not be done, due to poor response of the participants on the direction of knowledge flows with partners, apart from some that stated to be open source. Most likely this has its origin in an unclear questioning in the interviews. Therefore, the applicability of the framework is hard to determine for this element. The *functions element* was more successful, especially on the level of the holistic view on the system, because the virtual spaces of Knowledge, Innovation and Consensus could be exposed through mapping of which partnerships contributed to each space. Even a percentage of responsibility could be generated from the Consensus Space. However, it is unclear what such a percentage actually means, since there are no references to compare it with. Also, the responses on the question for the dimensions of anticipation, reflexivity and responsiveness are subject to some questions of validity, which has more to do with the operational activities of the research than the framework, but prevents a determined conclusion to be made of the functions element.

The overall applicability of the framework in this phase, therefore, varies per element. Another reason that questions the arguments for using the framework in this phase might be that responsible innovation activities, such as broad inclusion of stakeholders, might interfere with the short term progress of a project, because it takes time and resources to do this. This observation is inherent to the influence of Open Innovation, where openness sometimes hurts short time performances of firms. (Faems et al., 2010) It should be researched if the use of the responsible innovation framework during this phase really generates benefits, especially on the long term.

In the **implementation phase**, this last observation is also relevant, because end users do not want to waste time talking to all the stakeholders in the system, but they just want a good product. Therefore, also here the beneficiaries of applying the framework are unclear on the short and long term. Still some things can be said. In the *components element* the focus on capital creation, rather then institutional actors, was helpful to show which projects miss important building blocks for a sustainable project. This is especially the case with the determination of human capital, which is linked to education or the academic sphere. While no university was found for some projects, human capital creation was indeed present. Political capital was the most important one missing for all, endangering compliance with local government objectives. It also differed between projects where social capital was created, ensuring a better implementation in the society. In the *relations element*, a clear overview on the projects was given that have an open communication environment. In the functions elements, the task of showing the dimensions of anticipation, reflexivity and responsiveness could be determined with the help of the semi-structured interview, however it was difficult to assign a weight to these observations, because the one form of anticipation is not the other. Still, knowledge creation and innovation by participation with end users was also successfully observed. Apart from the questions on effectiveness of responsible innovation activities in this phase, the framework appears to have successfully determined the building blocks that are necessary for a responsible innovation system, especially because of the reflexively applied capital creation opposed to looking for the presence of institutions solely.

Concluding, the framework seems most applicable to the exploration phase, because here there is no trade-off between responsibility and effectiveness of activities that take up time and resources. Going to a responsible event and an irresponsible event, generally speaking, takes up the same time, making the responsible one preferable. However, while the framework did observe most of the desired building blocks of a responsible innovation system in the other phases, this trade-off of responsibility and effectiveness of activities should be further examined, before application of the framework on a wider scale should be pursued. Also, for the construction phase, both the relations and functions elements are subject to some operational concerns that prevent real conclusions on the applicability for that phase. These concerns on the applicability of the framework and the operational issues, are taken along to Chapter 8, where the validity of the research is further examined.

7.6. Summary of Results and Discussions

In what way can a case study show responsible innovation characteristics in India? - Both Chapter 6 and Chapter 7 have answered this question. Three types of data collection have been applied, conducted from the observation that the collective innovation process has three phases, namely an exploration, construction and implementation phase. Each phase was researched with a specific data collection, respectively, event visits, a structured interview with institutional organisations and a semi-structured interview with end users. Each data collection method is discussed from the perspective of the Responsible Innovation Systems framework elements, being components, relations and functions. Ultimately, the stage of the system could be determined and the conditions for a responsible innovation system could be evaluated, with the exposed evidence.

It could be concluded that arenas for exploration exist, where a responsible collective innovation process can be started for stakeholders of the rural energy technology sector. ICEGOV appeared to tick all the boxes that are required in systemic responsibility, according to the proposed framework. All institutions were found as part of the components element, two-way knowledge flow was discovered in the relations elements and in the functions element ICEGOV showed to contribute to all functional spaces, including enhancement of all RI dimensions. However, ICEGOV was a one-time event for India. Still, ISGW came close to ticking all the boxes too, with the exception of sufficiently including civil society actors. WWF climate solver had an interesting set up, with a clear inclusion of all stakeholders, but failed to address some RI dimension. The CERC public hearing for comments on draft policy appeared the least suitable for a responsible innovation environment

Also, because no government actor was found as participant in the research, despite contacting the REC, the BERC and the BREDA, the event visits have served as an observatory data input for a better look into government. It exposed that on the very top level, around Prime Minister Modi's council of ministers, the way forward of India towards creating a governance environment that is anticipatory, inclusive, reflective and responsive has been set in as could be seen at ICEGOV, where academics, industry and civil society all came together under the wing of government. However, the top-down descend towards local contexts is far. During ISGW it was seen that incumbent elements in the rest of government are preventing rapid change, because rural areas were not even mentioned at one of the largest events for the energy sector in India. The energy sector is mainly focused on urban areas, but needs to start prioritising the rural areas to, in order to make the targets that the top ministers are setting for them. Top level government appears ready for a massive transformation towards a modern form of governance, but can state and local governments get along?

The construction phase was analysed with a structured interview (Questionnaire Y) at organisations, where an extensive amount of data could be retrieved, of which here only the most relevant is mentioned. The components element of the framework showed that the industry and public institutional spheres are fairly well positioned, with a large amount of companies, social enterprises and NGOs. However, the institutions of university and government have not appeared next to the other two spheres in a manner that can be considered inclusive and responsible. Most participants do not directly connect to government or academia, leaving them absent in the constructing map. Since this observation of predominantly industry and civil society actors could be expected, also four higher level intermediaries were questioned, however, these also connected poorly to government and academia. Only two Indian technical universities were discovered to be working with all the participants in this research. Government has a few more actors on the system, but these are highly clustered around a few participants. Little direct connection of the electricity regulatory committee and the state nodal agencies, like BREDA and UPNEDA (Bihar and Uttar Pradesh), or the REC is particularly worrying, since these are exactly the actors that have been assigned the job of creating an inclusive and cooperative environment.

In the relations element of the framework, the influence of OI was limited, due to poor response on this subject. Only from the interview with CLEAN something could be said. CLEAN appeared as the most central actor, virtually tying the system together. However, it also became clear that it is having a large outbound knowledge flow and a small inbound knowledge flow. As OI literature has shown, these two combined with a central position predict an inefficient process and should be a high concern for CLEAN to solve. More inbound knowledge is required for CLEAN to deliver its own objectives.

With the help of the functions element of the framework these findings were further specified,

showing additional need for civil society to perform R&D for contributing to the Knowledge space and for government to be included in the Innovation Space more often. Finally, the Consensus Space showed the degree of responsibility in collaborations to be 33%, determined as the percentage of relations that contain activities that enhance the dimensions of anticipation, reflexivity and responsiveness. While it was shown that those RI dimensions can largely be discovered internally in the participants, there appears very little communication of the dimensions with partners and relations, which is essential to systemic responsibility. Still, a few participants are explicitly open source, which are the most important ones that contribute to responsibility of the system.

Finally, the implementation phase of the collective innovation process could be considered from the semi-structured interviews (Questionnaire X) with end users in the field. None of the project had a full inclusive component configuration, as the quadruple helix prescribes. Even the end users themselves were not included in the process in all projects. The rural energy technology projects that did include the end users showed clear benefits in the light of responsibility. Wherever there was more inclusion, two-way communication channels opened up, which are essential to transferring information regarding the dimensions of responsibility. With projects where customers were included, the other three dimensions of RI were much more noticeable. When included, customers increased activities on anticipation, reflexivity and responsiveness, with the community microgrid of Vayam as the best example, where the community was included from the beginning of the design stage. The community urges Vayam to further expand the system with running water, anticipating on a better village infrastructure. Reflexivity came much easier, since the community knew exactly what was asked of them, what Vayam could provide and who had which responsibility. The responsiveness increased, since the community became highly active in keeping the system working and were not at all dependent on an extension to the governmental grid, since they could provide for themselves. Additionally, some minor observations have served to answer the main research question, such as the role of government in these local contexts, which is sometimes rather depressing than invigorating.

With the help of these three data inputs it could be considered if the conditions for a responsible innovation system have been met. Several conditions seem to be in accordance, however many conditions still appear to be missing, with mutual trust, intellectual property protection and an open environment as most important ones. It shows how the innovation system of rural energy technology in India needs to develop in several aspects before it can truly become responsible. Before such claims can be confidently made, however, the validity of the framework and of the research needs to be addressed, which next chapter will see to.

Finally, some insights are shared about the applicability of the framework. It seems most applicable to the exploration phase, because here there is no trade-off between effectiveness of activities that take up time and resources. However, while the framework did observe most of the desired building blocks of a responsible innovation system in the other phases, this trade-off of responsibility and effectiveness of activities should be further examined, before application of the framework on a wider scale should be pursued. Also, for the construction phase, both the relations and functions elements are subject to some operational concerns that prevent real conclusions on the applicability for that phase. These concerns on the applicability of the framework and the operational issues, are also taken along to Chapter 8, where the validity of the research is further examined.

8

Validation & Generalisation

What are the threats to internal and external credibility of the research and what does this imply for further research? - It should be verified that the results of this study are valid and may be used to draw suggestions for other contexts. This part of the report is essential to discover shortcomings or confirmations of the methodology on several levels.

8.1. Approach to Validation & Generalisation

Validity in qualitative research has been approached in a variety of ways, but until today no single one has proven to be a one and only to ensure legitimacy. It can be argued that all validation methods are applicable to some qualitative research. It calls for an approach to validity with design specific conditions. (Onwuegbuzie and Leech, 2007)

In a research project there are three main stages, namely research design/data collection, data analysis and data interpretation. In quantitative research, the path through these stages is linear, however in qualitative research there are iterative processes happening that need to be taken into account, altering the way validity is done.

It might be said that in validity there exist threats to internal and external validity during these three stages, potentially decreasing credibility. (Onwuegbuzie, 2000) Internal credibility resonates with truth value, applicability, consistency, neutrality, dependability, and/or credibility of interpretations and conclusions. External credibility resonates with the degree that the results can be generalised across different populations of persons, settings, contexts, and times. It relates to the confirmability and transferability of findings and conclusions.

Onwuegbuzie and Leech (2007) have merged a set of known qualitative validation methods into a framework that spawns from these internal and external credibility perspective that will allow for a simultaneous validation and generalisation of the results of this thesis project. Figure 8.1 shows the model.

Although the Qualitative Legitimation Model is comprehensive, it is by no means exhaustive. The researchers encourage users to find ways to improve upon this framework. Still, in any particular qualitative study, not all of the threats contained in the model will be pertinent. Unlike in quantitative research, where the goal is to minimise all sources of invalidity, different validity components of the Qualitative Legitimation Model will be relevant in different qualitative studies. In this chapter the different validity types of the model will be discussed for applicability to this project and the threats or the methods that prevented threats shall be exposed.

As will become clear, not all threats to validity could be determined. In such cases, the recommendations sector allows for a small consideration on how this should be reached, if is determined that such validity is necessary. Furthermore, it will be seen that a certain validity type appeared to be missing, namely that of 'integrity validity'. The framework of Onwuegbuzie and Leech is therefore extended as well, with insights from the case study.

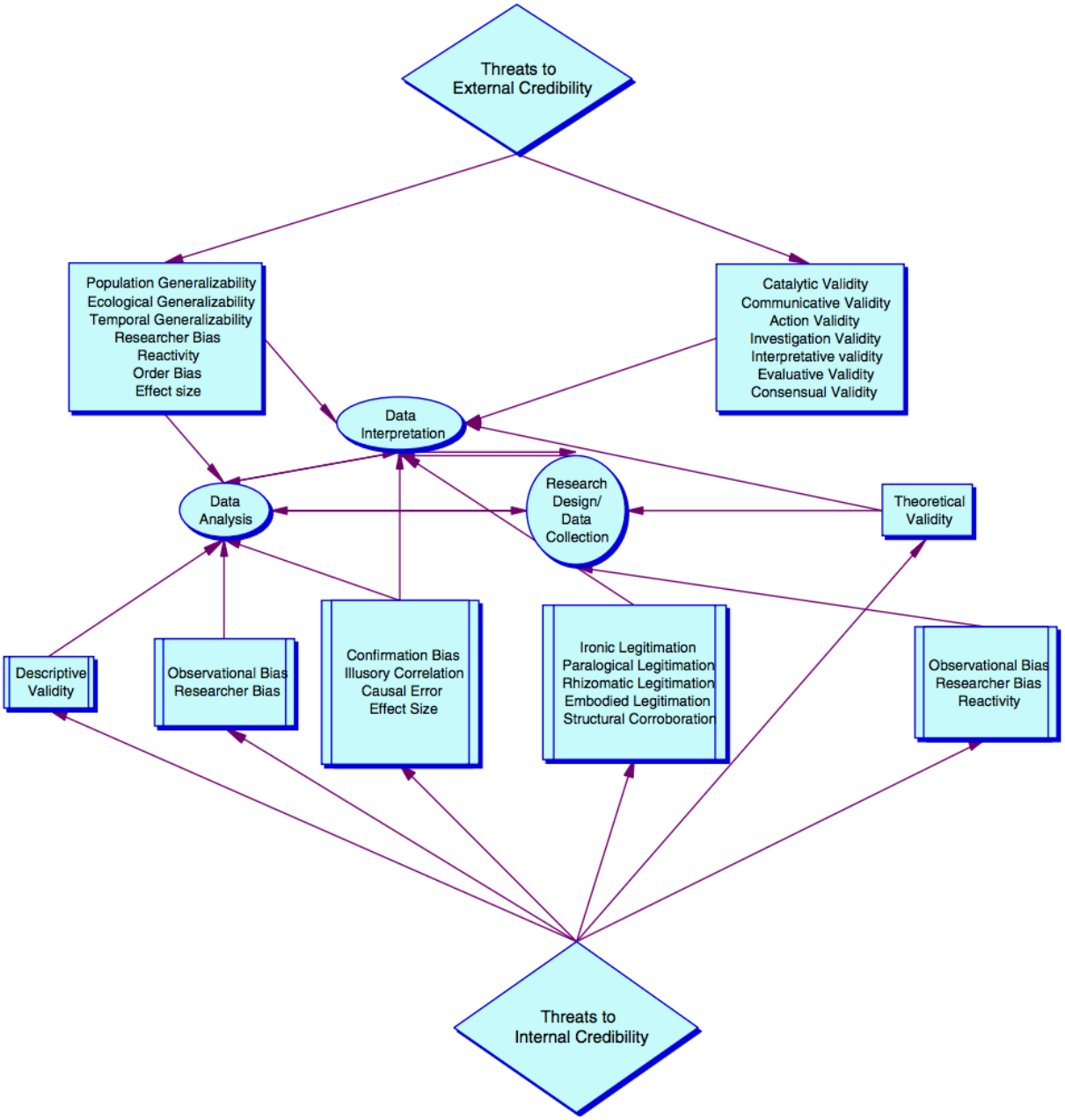


Figure 8.1: Qualitative Legitimation Model (Onwuegbuzie and Leech, 2007)

8.2. Internal Validity

A number of qualitative legitimacy methods can be prescribed to internal credibility. Ironic legitimation, paralogical legitimation, rhizomatic legitimation, embodied legitimation, descriptive validity, structural corroboration, theoretical validity, observational bias, researcher bias, reactivity, confirmation bias, illusory correlation, causal error, and effect size are all explained and discussed for possible influence on the internal validity of this research.

Theoretical validity

The theoretical explanation developed from research findings should be credible, trustworthy, and defensible. (Maxwell, 1992) The theories from which the Responsible Innovation Framework have been built should therefore be logically combined.

In Chapter 3 a careful combination is done. The theoretical validity could be in danger whenever the most important assumption is found unstable, where it is assumed that an innovation system is responsible when it behaves as an open knowledge network that allows for the Quadruple Helix to emerge and the regional innovation system to develop, while the dimensions of anticipation, reflexivity, inclusion and responsiveness are internally and mutually shared among the actors. However, this synthesis of theories was done with a careful look at the critiques on each one. It appeared that the shortcomings of each could be counteracted by the other theories. This way a robust conceptual basis was found, that also gets the support from a wide range of scholars, among which Grundel and Dahlström (2016). Still, if somewhere after the end of this research new evidence comes along that undermines the status quo on Responsible Innovation, Open Innovation, Triple/Quadruple Helix and Systems of Innovation, it will be necessary to evaluate the conclusion of this research too, since it can have corrupted the research design and the data interpretation.

One important limitation that remains from the combination of the complementary theories is the insufficient taking into account of intellectual property, as Table 3.4 shows. Therefore the research fails to deliver a framework that companies can use in setting up collaborations and opening up their innovation processes.

Finally, another important threat to theoretical validity is that the components part of the framework can only be addressed with contribution to a certain institution. This has made it that social enterprises are in the same group of institutional configurations as impact investors, for example, while these are profoundly different organisations. It is recommended to do a study where these differences are specified further. A consideration of adding the framework of Functions of Innovation Systems (FIS) might be done, where each actor is assessed on its function in the system. (Hekkert et al., 2007)

Descriptive Validity

This refers to the factual accuracy of the documentations by the researcher. (Maxwell, 1992) Here some considerations are important to note.

The description of the institutions and especially the intersection of institutions as part of the components in the framework is fairly general, also resulting from theoretical validity. A further distinction of actors might be necessary. Most NGOs are different from farmer cooperatives, banks are different from production factories, state nodal agencies are different from ministries and universities are different from research centres, while each two actors in the pairs currently fall under the same institution. At the intersection these descriptions become even more diverging, where social enterprises are in the same institutional configuration as impact investors and CLEAN is considered the same type of organisation as the German development agency (GIZ), while they are fundamentally different organisations. Descriptive validity can therefore also be solved with an extension of the framework with more characteristics for actors, such as the Functions of Innovation Systems. Hekkert et al. (2007)

Furthermore, the questions that meant to expose RI dimensions were fairly rudimentary for the complex activities that can underlie these dimensions. While the questions allowed for a broad intake on what a contribution to either of the dimensions means, it also paved the way for unclear answers on these questions that had to be described in terms of what that contribution was. This was partly due to the vague definitions of the dimensions supplied by literature, especially for use in the context

of emerging countries. Therefore, it is questionable how well the questions were able to expose the contribution to the RI dimensions, because certain activities of participants might have not come up due to failing of linking those activities to the asked characteristics. It argues for a better definition of the dimensions and the resulting questions that should be asked. The inclusion dimension, however, has not faced this threat, due to the objective consideration that could be done on partnerships in the system.

Ironic Legitimation

This sub section and the three following are guided by validity types conceptualised by Patti Lather, from a work called: *Fertile Obsession: Validity after Poststructuralism*. (Lather, 1993) It is a very abstract approach towards validity, with prevailing terms as 'hyper reality' and 'verisimilitude' being evidence of that. However, when one pokes through the poetic sentences, some interesting thought experiments become visible. The first one being ironic legitimation. It spawns from the concept of simulacra. Something that is a copy, but no reference to an original exists, concealing truthfulness and being a perfect fake. It rests on the assumption that multiple realities of the same phenomenon exist and the truth value of the research depends on the revealing of co-existing opposites.

For this internal credibility to hold, it must therefore be discovered, for example, that there exist other systems, for example where government and academics spheres are intersecting, but industry and public are lacking. Hints of that have been seen at the ICEGOV event, where top level government was cooperating with academics. However, this was not specified on the rural energy sector exactly. Ironic validity is therefore not ensured. It is advisable to start a new project that takes an initial start from the government and university spheres.

Paralogical Legitimation

Again Lather comes with a very abstract approach in paralogical legitimation. Whenever a researcher can show that a movement against an established way of reasoning has been tried, this validity is reached. Paradoxes might come up that in the eye of the beholder should be solved, but in paralogical legitimation differences are fostered and tensions are kept in place. (Lather, 1993)

One paradox that was found during this research is when openness of networks is considered. The general line of thinking is that openness creates a more responsible system, however it was also found that the openness can also make the operations sub optimal and even loss making, creating a less responsive and thus less responsible situation. This paradox, however, was left intact and even explained with the research on echo chambers by Alex Pentland, verifying that openness can lead to both responsible and irresponsible situations and the tension between open and closed needs to stay intact. (Pentland, 2014) However, the influence of this tension still exists in the question whether responsible innovation activities should be pursued in the construction and implementation phases, because of the threat that more responsibility will give less responsibility, due to the dimensions of responsible innovation counteracting each other.

However, the other dimensions of RI could have served with a better explanation on this, as was also mentioned in the descriptive validity sub section. In the proposing paper of RI, the scholars already mention these paradoxes, since activities might contribute to one dimension and decline another. (Stilgoe et al., 2013) There has not been any deeper evaluation of these statements, apart from the finding on openness. Therefore, the paralogical legitimation of activities both contributing and hampering responsibility might be further examined, which also would serve create better application of the framework in the construction and implementation phases.

Rhizomatic Legitimation

Again a difficult name that Lather comes up with, but once explained, its relevance will be clear. (Lather, 1993) Rhizomatic legitimation becomes relevant whenever a mapping of data is done. This research has made extensive use of the mapping of data, especially in the open source network programme of Gephi. Lather shows that it can be suggested that the modernist model of knowledge production takes the shape of a tree, but the post-modernist model that of a rhizome. (Deleuze and Guattari, 1983) It becomes relevant whenever societal structures change from hierarchies to networks. Arguably, that is currently happening throughout the decentralising globe. Figure 8.2 visualises this difference in

knowledge model from nature's perspective.

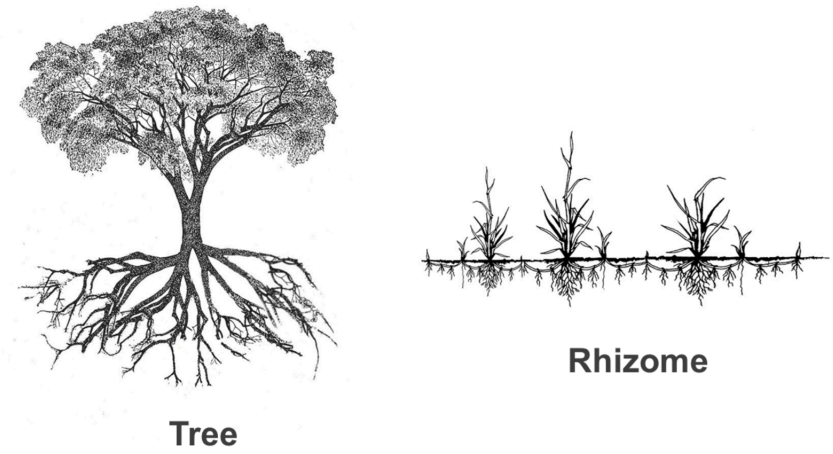


Figure 8.2: The difference between a tree and a rhizome, as might be applied to knowledge models (University of Toronto, Faculty of Architecture, 2013)

Rhizomatics is a journey among intersections, nodes and regionalisations through a multi-centered complexity. (Lather, 1993) The attending reader will see the parallels with many of the key concepts in this report. The emergence of a responsible innovation system is allowed by open knowledge flow in a network between nodes defined in the quadruple helix of institutions that intersect in regional contexts. Rhizomes and decentralised networks are often mentioned in relation to fractal behaviour, connecting the dots towards the mode 3 knowledge production model that Carayannis and Campbell described. (Berntson and Stoll, 1997) (Carayannis and Campbell, 2009)

This image can be clarified by the figure above. One could visualise each emerging 'crown' in the rhizome network to become a self-sustaining branch in the form of the emerging quadruple helix. Theory has actually predicted that such fractal patterns in networks are happening, adding to rhizomatic legitimation. However, to further legitimise, further research could try to expose more of these structures, by taking other intersections of the innovation system. Relating to what was said in the ironic legitimation, sub systems could this way be discovered with stronger government and university spheres or other configurations. It would be advisable to take other nodes as the focus point. GIPU actors should be chosen for this, because they are most likely at the centre of these emerging branches, like the Aga Khan Development Network, IRENA, Power for All, Development Alternatives or the Energy Access Practitioners Network, all seen in Figure 7.3. Still, by including SELCO and DESI Power as participants, which are among the oldest actors in the system, it is likely that the origins of the rhizome network have been captured and the found connections are the larger part of the truth.

The rhizomatic legitimation has shown that the observations regarding the responsibility of the system in this report should be converged towards saying that the particular branch that was researched in the rhizomatic innovation network is not behaving responsibly, instead of claiming that the whole system can be described. However, from the assumption that for the whole system to reach responsibility, each part must be responsible, the conclusion may still be generalised towards the whole system.

Embodied Legitimation

This last legitimation by Lather, also called voluptuous legitimation, is related to the knowledge of the researcher. It assesses whether the level needed for interpretation of the data exceeds the knowledge base that is internally available in the researcher. (Lather, 1993) As an example Lather gives the concept

of the male imaginary and the female imaginary that contain fundamental differences, especially in relation to research on feminist activities. Such a research would benefit from a combined imaginary of both sexes. For this research such line of thought becomes relevant on several levels. Firstly, regarding the topic of research. Secondly, because of the distance that exists between India and The Netherlands.

The knowledge base of the researcher on rural energy technology can be assumed sufficient, due to the master programme on Sustainable Energy Technology and an extensive internship on the topic for Rural Spark. Previous to this thesis, however, the academic approaches towards responsible innovation, innovation systems, helix theory and open innovation were completely unknown for the writer of this report. A weakness could be that several insights needed for the synthesis of a responsible innovation systems framework have remained undiscovered, which should have been taken into account. A careful reading by scholars with additional expertise on these topics might expose flaws in the combined theory approach. Therefore such experts are very much invited to share their views on possible gaps or flaws.

With respect to the Indian context, it should be clear that no previous experience with this country existed for the researcher. In collecting data, certain ways of communication might have been interpreted differently then intended, because of internal lack of knowledge on local ways of practise. For the field visits, this threat has been severely reduced due to the active presence of an interpreter and discussion partner that had great knowledge of local contexts. However, the questionnaires were conducted without this interpreter and have been subject to the interpretation of the researcher alone. One of the threats to such communication that was at least prevented was the discovery of the government's definition on village electrification. The prevailing definition was thought to be electrification of the whole village, while in the context for the GoI it is only 10% of the village. It might be expected that more of these misconceptions are present, due to lack of knowledge of the Indian context. It is requested to readers that have noted any flaws to subsequently share these.

Another embodied legitimation threat does not come from the researcher itself, but from the Responsible Innovation Systems framework itself. It is the first time the framework is used in a case study, which has not given it the chance to mature from an iterative process through different cases. This validity helps to conceptualise the framework as a knowledge containing entity, which needs to be expanded. It also emphasises the importance of the insight that the framework is not yet matured.

Structural Corrobation

In structural corroboration, multiple types of data collection methods are used to support or to contradict the interpretations. (Eisner, 2017) This type of validity increases if these different types of data collection come to the same conclusions.

Three different types of data have been collected in the research. Event visits, a structured interview and a semi-structured interview. Similar conclusions to the role of the institutions could be drawn in the different parts of the collective innovation process. However one of the event visits (ICEGOV) might have hinted towards a potentially different branch in the innovation network where on a top level government and university are cooperating. It appears that the overall validity has been increased by this approach, while also generating material for further suggestions, like the presence of other sub systems.

Observational Bias

Observational bias happens when a data collector has not obtained sufficient sampling of the behaviours that are of interest. (Onwuegbuzie, 2000) It should be verified that the amount of participants in this research is enough in order to make conclusions without observational bias. This can be discussed for all three types of data input.

The event visits contain a rather diverse set of institutions. India Smart Grid week emphasises on government and industry, ICEGOV focuses on government and academia, with some industry and civil society, the CERC hearing is fully focused on government and the WWF climate solver tried to include all institutions. Still the event visits might have been enriched with an event slightly more focused on organisations that are building social capital, however this is only a minor addition.

In the interviews with organisations some threats to observational bias exist. As mentioned earlier

in Chapter 7 there exists a bias towards the intersection of institutions of industry and public, since 13 out of the 17 participants operate as social enterprises. For a fully unbiased perspective, there should be an even amount of interviews with any institutional configuration as defined by the quadruple helix. However, where the framework requests interdependence of all institutions and interconnections are at least required for that. The conlusion should only count for the found intersection of the system, whereas a fully inclusive sussystem might still exist next to this one.

A large enough sample size would decrease the threat of observational bias too. So, how well does the visualised innovation system represent the true innovation system of rural energy technology? CLEAN has claimed responsibility of connecting the whole energy access sector in India and not a better suitable archive of active players in the field could be found. About a third of the members presented on CLEAN's website are appearing in the maps produced with Gephi. Despite interviewing CLEAN, not all members were accounted for, because of this attempt to find out which percentage of actors in their network could be separately discovered, so that a impression of the found system could be made. It is therefore assumed that the found intersection of the system also represents about a third of the true size of the innovation system. It is left open to explore the rest of CLEAN's ecosystem in later stages, to discover the complete system.

Regarding the field visits, five projects were visited. However the nature of these projects diverged to some severe extend. One microgrid, one solar irrigation plant, two solar home systems and one smart meter installation were visited, meaning that most types of rural energy technology only had one perspective. It would serve to decrease observational bias by visiting more projects of all these rural energy technologies by a prolonged engagement with stakeholders in these projects.

Researcher Bias

The researcher bias relates to the personal bias that might be intrinsic to the researcher and can emerge in conversation too. It is mostly relevant in the data collection stage. Both active and passive bias can be discovered, where passive is in the researchers personality and preferences, because active can be found in the statements that might indicate these preferences. (Onwuegbuzie, 2000)

Up front there existed a possible conflict of interest for the researcher, due to the strong relations with one of the participants. Rural Spark both participated and facilitated the research by providing the financial means to travel to India and allowing use of their office during the stay. From the start it has been discussed with Rural Spark that there should be as little as possible potential for bias or conflict of interest towards their company, in order to keep the playing field level. It has therefore only been sparsely communicated to other participants about the close relations with Rural Spark and whenever it came to the table, it was always emphasised that an unbiased position was taken and any participant was treated equally. Rural Spark always indicated that this is exactly the way they wanted the research to be. Still, that does not mean that the bias is gone. If anything, the knowledge exchange between Rural Spark and the researcher has been the most open of all, thereby allowing the data to be the most truthful of all.

Other than that bias with Rural Spark, the researcher had no connections or interests in individual projects in India. He only had interest in making the innovation system of rural energy technology as responsible as possible.

Reactivity

Reactivity responds to the way in which a study is undertaken and the reactions of the participants involved. (Onwuegbuzie, 2000) Participants can be influenced by knowing that their responses are being recorded and could alter their answers in this regard. Simply the presence of observers and recordings can initiate this behaviour. Normally this type of threat to validity is seen as external, however, Onwuegbuzie argues that respondents could create rival explanations for findings that threaten internal validity at the data collection stage. Two major components of reactivity can be discussed, namely the *Hawthorne effect* and the *novelty effect*.

The Hawthorne effect relates to the interviewee thinking that they are getting special treatment by the interviewer and therefore making it difficult to differentiate natural occurring behaviour and constructed responses. This threat has been minimised by keeping it open to all interviewees who is participating

and by stating that the research is meant to serve the entire innovation system, not only the interviewee. With the field visits this was expected as well, because the locations were chosen by the companies. The interpreter tried his best to break the through the possibility of, for example, positive statements about the company that provided the rural energy technology products.

The novelty effect has to do with situations that people have not experienced before, such as the presence of a video camera, which might trouble true responses. Especially during the field visits it was found that no foreign researcher had ever visited the communities. To take away the focus on that novelty, during some parts of the interviews the interpreter took the lead, while the researcher was in the background making notes in an old-fashioned notebook. Furthermore, open questions were asked that left space for new questions and topics to emerge. Afterwards it was discussed with the interpreter which responses might be based on artificial stories or comments, so that this risk could be minimised in the conclusions.

Confirmation Bias

Confirmation bias happens when the researcher's interpretation of the data leans towards confirming presupposed conclusions to the research. (Greenwald et al., 1986) It is a threat to internal validity if there exists at least one opposite explanation that to the made conclusion.

This opposite explanation could not be discovered. The inclusion dimension proved to be the most tangible and objectively measurable variable, and those results argue that the inclusion dimension is not contributed to sufficiently in to reach responsibility.

However the other three dimensions lack clear definition and create a minor threat. Some companies opened up their processes much more than others, allowing more observation of their operational process. The companies that allowed fields visits, for example, were already contacted with the semi-structured interview. Their openness towards this research might have influenced the evaluation on their openness towards end users.

This bias can be measured by replication of the research by other researchers, after which inter-rater reliability could be determined. (Saal et al., 1980) Several techniques exist to statistically determine agreement between researchers, and thus inter-rater reliability, however these are not relevant to discuss here.

Illusory Correlation

The illusory correlation relates to a tendency of identifying relationships among events when no such relationship actually exists. Such an illusory correlation is a serious threat to internal credibility at the stage of data interpretation.

A potential illusory correlation can be appointed in this research. The conclusion from the field visits that more inclusion might be the gateway dimension for the other RI dimensions to merge can certainly be contested on the base of a too small sample size alone. However, at the system level this can be recalled, because no systemic RI seems to be possible without inclusion in the system first.

Finally, some arguments done for the accordance of the conditions to a responsible innovation system might be based on some imaginary correlations. In other validations, in the external validty section, these illusions could be enlightened

Causal Error

Qualitative research often gives causal explanations for observations without trying to verify such interpretations. (Onwuegbuzie and Leech, 2007) In this research, however, such explanations are not often done. Furthermore, whenever explanations are sought, it is always added that such explanations 'seem' to be apparent or 'might' be happening, never claiming the truth of situations.

Effect Size

Effect size involves the incorrect interpretation of statistical significance. (Onwuegbuzie, 2000) While this type of validity is more common in quantitative research, it can be argued that adding effect sizes to qualitative research is valuable as well and some frameworks can be used. (Onwuegbuzie, 2003) The frameworks that Onwuegbuzie describes, however, could not be included in the limited time that this thesis projects spans. In a potential subsequent step, effect sizing might be added to further

validate the results of the project. Still, it might be questioned if this type of validity is fully applicable to the type of exploratory research that has been done here.

Concluding Internal Validity

After the many complex and diverse internal validity types, what can be said? At least, there does not appear to be severe threats to validity by researchers bias, causal errors, structural corrobation, and reactivity, while confirmation bias and paralogical legitimation should be examined further. Effect sizing does not appear to be of importance in the context of this research. Some treats, however, could be discovered.

Theoretical validity is threatened by the way that actors are characterised in institutional configurations, which puts actors with completely different activities in the same box of analysis. Furthermore, there is no taking into account of intellectual property in the framework, wondering what the use might be for companies in setting up responsible innovation activities in an open environment. *Descriptive validity* is endangered by the poor characterisation of actors in the theory and how contribution to the dimensions of responsible innovations is specified should be revised to improve on this validity type, because now there was only a broad intake of what such contribution means. *Rhizomatic legitimation* threatens the validity of the framework, because its usefulness becomes endangered because it does not allow for a generalisation of results from the framework of a small sample size towards the larger system. *Observational bias* exists, because only a small segment of the innovation system is questioned, mainly from the perspective of social enterprises acting in the Industry and Civil Society spheres, while also the field visits only showed one project of most technology types that rural energy technology contains. *Illusory correlations* exist in the observation that more inclusion also spawns more contribution to the other RI dimensions, as well as the observations on the conditions of the framework. *Ironic legitimation* was not ensured, since it could not be established, for example, that there exists a sub system where government an academia are highly cooperating. *Embodied legitimation* has several threats, on the academic knowledge base of the researcher and his cultural knowledge base. Also the framework itself can be seen as a knowledge containing entity, what would show that the immaturity of the framework needs to be addressed. The framework is used for the first time in this initial case study, which makes it an new tool that has not been subject to widespread questioning on its applicability.

8.3. External Validity

External validity resonates with the degree that the results can be generalised across different populations of persons, settings, contexts, and times and the confirmability and transferability of findings. Several elements of external validity can be described, namely catalytic validity, communicative validity, action validity, investigation validity, interpretive validity, evaluative validity, consensual validity, researcher bias, reactivity, order bias, and effect size. Officially part of the external validity in the legitimation model are the different generalisations, however, these have been given their own section in this report.

Catalytic Validity

Lather again comes with a contribution to the world of validity. The term catalytic validity is introduced, which is the degree to which a given research empowers and liberates a particular research community. (Lather, 1986) It relates to what barriers in theories of current research are being lifted and what pathways for new research are opened, acting as a catalyst for these processes. In practical, it includes how the respondents of the research are re-oriented, focused, and energised in what Freire (1973) calls ”conscientization”, meaning to know reality in order to better transform it.

Starting of with the theoretical contribution. Within the Responsible Innovation paradigms, this research potentially adds and important part towards describing responsibility on a systemic level. It does so by building a bridge from Open Innovation, for which systemic dynamics were not described before either, towards Systems of Innovation and Helix theories. Previously Responsible Innovation and Open Innovation were mostly focused on inter-organisational processes. The switch to more intra-organisational processes opens up possibilities for further research.

In the practical sense, for the respondents and stakeholders of this system this research will give a holistic approach, with which a better evaluation of their innovation processes is possible and shows what types of knowledge (or ’capital’) might or might not be flowing through their boundaries. It offers a more analytic approach towards selecting partners that will result in a more inclusive approach,

after which the anticipation, reflexivity and responsiveness dimensions can more easily be applied and diffused through the system, eventually generating a systemic responsible innovation process.

Communicative Validity

As Kvale (1995) describes, communicative validity is testing the validity of knowledge claims in a debate with others. In other words, validity is agreed upon by a group of interested researchers. This can only be reached in later stages, where the results are debated, which for now, has not been done.

Action Validity

Kvale also describes action validity. (Kvale, 1995) Justification of of the research can be based on whether or not it works. If the research findings are used by decision makers and other stakeholders, its existence might be validated.

Again here, this validation can only be fully reached in later steps, when the results have been presented to participants. However, some of the feedback on early documentation of results has been positive towards the use of it for the participants themselves, despite the complexity it might have for those unfamiliar with innovation theories. Still, a later evaluation process is needed after participants have had the time to process the information and decide on subsequent actions, for example through a survey on how helpful the insights of the report were.

Investigation Validity

Investigation validity is the quality control that a researcher has installed within the research. (Kvale, 1995) Not only is it a matter of the methods used, but also of the researcher's personality, including her or his ethicalness. Arguably, this validation step is more suitable to be performed by another individual, opposed to the researcher himself. However, something can be said, relating back to the morality mentioned in the introduction.

So what ethics have been applied? When investigating responsibility, it would be hypocritical not to design one's own research project in a responsible way. The objective was, therefore, to make the research anticipatory, reflective, inclusive and add to responsiveness. Chapter 9 sees to possible future strategies that would serve a responsible innovation system, creating anticipation of what the system becomes and how it could happen. Also, the participants get a clear image on what their current configuration is, adding to the dimension of reflexivity. To be inclusive, the research should be relevant to all institutions, of which can be argued that it is. While not every institution was interviewed, each institution has been analysed and evaluated, creating insights for all institutions. Finally, by creating a larger knowledge base on the ecosystem of rural energy technology, the system is more equipped to respond towards becoming more responsible or remaining responsible, for example when an important institutional partners falls away. Therefore, it might be said that this research has done a responsible contribution.

Some additional quality control mechanisms have been used as well. Not all interviews in Questionnaire Y could be done in person, which created the need for a clearly structured online questionnaire. This was always accompanied by a phone call to explain the research in detail. However, this has potentially troubled the understanding of participants of the true intentions. Therefore, there has been a post-interview evaluation of the answers given by the interviewees on the topics of institutional types, geographical position and R&D activities of relations. From public information in reports, websites, mission statements, generic information and the general activities have been consulted to validate the answers of the respondent in question. Many corrections could be done, since respondents appeared not to be aware of certain processes or thought it was not relevant to mention, or even misinterpreted the definitions that are being used.

Interpretive Validity

Interpretive validity refers to the understanding of the perspective of the group under study and the meanings attached to their words and actions.(Maxwell, 1992) Methods that can be tried is to use the words and concepts of the people studied and judge the study's accuracy based on their perspective. The socio-technical value map that was created in preparation of this research helped to reduce this threat, by creating a communication strategy, as seen in Appendix B.

During the field visits with Questionnaire X, this type of validity was again reached by the presence of the interpreter, who is a local and understands the local language and culture. Every interview was completely done in the local language and often simplified to questions that were better suited to discover the required phenomena, as was completely understood by the interpreter.

The parts of the Questionnaire Y that could not be checked with public information and are reliant on only the perspectives of the respondent are a threat to validity. The columns of the 'year of start collaborating', the 'frequency of contact' and the 'type of relation' in the questionnaire can all be questioned to have resulted in invalid answers. Despite trying to minimise the possibilities for respondents by designing the questionnaire with several options in the form of a drop-down menu, at later stages discoveries were done that questioned the answers. This is because not the right definitions were made clear to the participants or the respondents were missing information themselves that they did not retrieve from others within the organisation. Also, the different types of knowledge created by the different institutions, expressed as political, economic, social and human capital, as derived from Carayannis et al. (2012) needed to be found and with Open Innovation influences their directions should have been determined. The question in Questionnaire Y that tried to expose these knowledge flows has resulted in unusable or no answers, probably because the concept of knowledge flows was unclear of unfamiliar with the respondents. This has diluted the use of Open Innovation in the construction phase of the collective innovation process and is a recommendation to improve.

The questionnaires would have been served by a better description of the concepts that were being used, possibly in an accompanying document. Another problem that was detected is the presumable pride that sometimes stands in the way of admitting to not knowing something, relating to the next validity.

Integrity Validity

This validity type has not been specified in the original framework of Onwuegbuzie and Leech (2007), but has proven to be of relevance in this research. Answering untruthfully, incompletely or wrongly due to lack of trust, lack of openness, hasty completion or misinterpretations of upfront information is a serious threat to the validity. An environment that is not integer, open and informed can hardly be called responsible. Apart from consulting multiple respondents within organisations themselves or checking the partners they are describing, not much could be done to cross-reference some of the answers that were given.

Especially with the case of Mera Goa Power, many additional relations were discovered after the interview had already taken place. ONergy has not provided an industry partner, but they do distribute their owns fans, for example, that still need to be bought or produced at an industry partner. Also, some interviews were filled in by employees, who might not have the full overview of relations, but have not admitted to giving an incomplete image, despite asking to provide this insight. J-Pal is the only participant who specifically mentioned that there might be more relations that the respondent in question did not know of. On the other hand, while there might be some changes to specific relations if this threats would be better managed, the overall impression on the responsibility of the innovation system is not likely to fundamentally change.

Evaluative Validity

This validity type concerns whether the researcher was able to describe and understand the data without being evaluative or judgemental. (Maxwell, 1992) Ethical or moral frameworks to interpret data can be used for judging these accounts. Evaluative validity looks away form the data itself and tries to assess the evaluations drawn by the researchers.

Apart from the moral guideline of wanting to contribute responsibly with this research, no ethical or moral frameworks have been set up to prevent evaluative threats. Especially with the questions regarding RI dimensions and conditions, this evaluation part has been very strong. Due to the vagueness of the subject, reading between the lines was necessary to come to workable answers. It shows, again, that for the decisions made on assigning anticipation, reflexivity and responsiveness to the processes of participants, validity is unstable, due to the large degree of judgemental consideration, induced by vague descriptions. It will therefore be difficult for other researchers to replicate that part of the questionnaire. The far more objective part of the questionnaire on inclusion had already determined the system is not equipped to transfer the other three dimensions sufficiently across the system, due to a lack of cooperation between institution, not making this a huge threat to the most important observations. However for the next evaluation of the system this part needs to be improved.

Consensual Validity

Consensual validity is defined as the confirmation of reality by comparison of one's own perceptions and concerns with those of others, including the recognition and modification of distortions. (Eisner, 2017) Again, this type of validity can only be reached with the help of multiple individuals.

However, a research paper was found that analyses the cooperation of the Triple Helix institutions in India for a number of sectors, including those relevant to rural energy technology. (Rupika and Singh, 2016) It might be assumed that the researchers of this project will agree with the findings of structural lack of collaboration between institutions, which was found in the research.

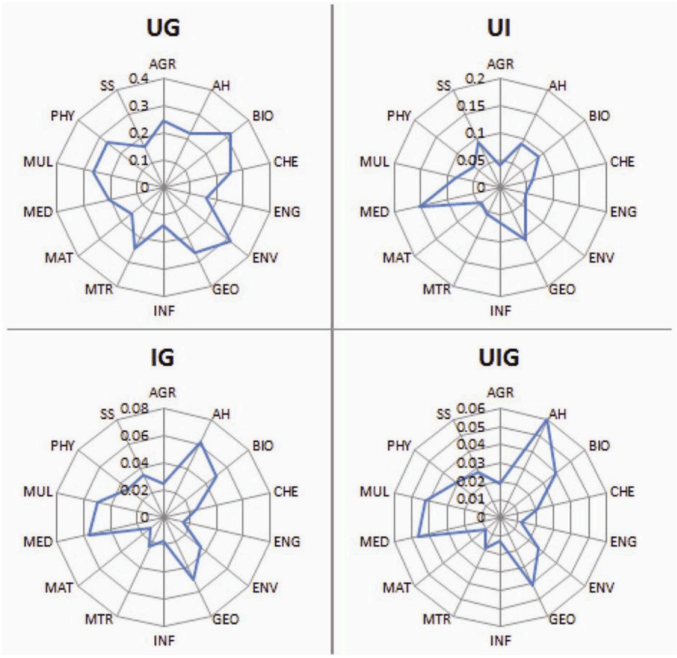


Figure 8.3: Category-wise output variations of different collaboration sectors in India (Rupika and Singh, 2016)

By analysing publications from 2005 to 2014 on their collaborative configuration of government-industry-university (GIU) the scholars try to measure collaboration. Figure 8.3 shows the results per sector, of which the relevant abbreviations mean the following in combination with the found strength:

- SS - Social Sciences - *Weak in all*
- PHY - Physics - *Moderate in UG - Weak in UI, IG, UIG*
- MAT - Mathematics - *Weak in all*
- MTR - Material sciences - *Moderate in UG - Weak in UI, IG, UIG*
- INF - Information sciences - *Weak in all*
- ENG - Engineering - *Weak in all*
- CHE - Chemistry - *Moderate in UG - Weak in UI, IG, UIG*
- MUL - Multidisciplinary - *Moderate in UG, IG, UIG - Weak in UI*

Looking at these results, it can be assumed the debate will turn out into consensus fairly quick. Even though civil society is not included, it is evident that there exist weak linkages between the institutions, as was found during this thesis too. All mentioned sectors have some sort of influence on the development of energy technologies, giving it extra weight that especially these sectors are

not performing well, compared to MED (medical sciences) or AH (arts and humanities). Rupika and Singh (2016) also discover that during the past years, collaboration has actually gone down for most configurations, except for IG collaboration. It expresses the urgency of a more inclusive approach to innovation for the institutions in India and institutions adopting practices to increase collaboration.

Researcher Bias

Researcher bias, as was earlier described for internal validity, also threatens external validity, because the particular type of bias of the researcher may be so unique that is becomes impossible to generalise the findings. Already it was determined that researcher bias was minimised, therefore this threat can be considered irrelevant for generalisation.

Reactivity

Also earlier described in internal validity, the reactivity was minimised in several ways. Through asking open questions and expecting answers that would be untruthful, this threat has been dealt with extensively. At the same time it was left unsaid what exactly was considered to be a 'good' result, so that interviewees did not steer their answers to this.

A prevalent example of this during the field visits was with the shop owner in Bhodghaya. After asking what the shop owner thought about the smart meters, he answered 'it is good'. By specifically asking him why he thought this, the interviewee was forced to give arguments and reveal more truths. It revealed that there was very little knowledge on what the smart meter was and could do, since he could not explain what was so good to him.

Order Bias

Order bias happens when the order of the questions influences the response of the participants. If this happens, outcomes cannot be generalised.

With the Questionnaire Y for the organisations, the questions were always fully shared at forehand, meaning that the order bias is not relevant. With the semi-structured interview of Questionnaire X, the order of questions was not maintained across the cases, making this bias impossible to evaluate.

Effect Size

As explained at the internal validity description of effect sizing, this technique has not been used and could be applied in further stages of developing responsible innovation systems to better validate the results, however, the usefulness should be questioned.

Concluding External Validity

There does not appear to be a direct threat to validity by researchers bias, reactivity, order bias, catalytic validity, investigation validity and consensual validity, while communicative validity, action validity and effect sizing could not be determined or were irrelevant. Some threats, however, could be noted.

Interpretative validity is a threat, since the researcher needed to interpret a lot of data from interviewees who could have misunderstood the definitions or lacked sufficient knowledge, making the data about something else then the researchers thinks it was about. *Evaluative validity* is endangered by the necessary reading between the lines, where sometimes assumptions had to be made according to contribution to the dimensions of anticipation, reflexivity and responsiveness. Lastly, *integrity validity* is threatened, because it was found on multiple occasions that the data provided by the interviewees was untruthfull, incomplete or wrong, possibly due to lack of trust, lack of openness, hasty completion or misinterpretations of upfront information.

8.4. Generalisation

Although in the framework of Onwuegbuzie and Leech (2007) the generalisation is positioned under external validity, in this report a separate section is devoted to it. They mention three types of generalisation, namely different populations, locations and times. Adam and Groves (2011) state, that the past and the present do not provide a reasonable guide to the future in the event of innovation. This makes trying to generalise innovation research a difficult task, because it could be very case-dependent. It could, for example, be that the solar energy sector in India, which is very closely related to the rural energy sector, generates completely different results with the use of the same framework. Also, as suggested by the rhizomatic and ironic legitimation, even within the same context different

results might be found. Therefore, the generalisation will only focus on the developed Responsible Innovation Systems framework and not so much on the generalisation of the results.

In Section 4.2.5 certain conditions have been set up to which the contextual characteristics of a system must comply, before a responsible innovation system might emerge. The use of the framework might be generalised towards any part of population, region or time where these conditions apply. However, the conditions were not in order for India either, while still the framework was used. The framework in a way helps to expose the compliance of some of the conditions, because of the integral assessing evolutionary component.

It invites to say that the framework is applicable to any context where innovation of products and processes, knowledge creation and institutional configurations of society exist, or in other words, where a knowledge democracy can be established. This is very broad and should normally not be regarded sufficient as an answer in a chapter like this, however, it can be reasoned. The theories that combine to the Responsible Innovation Systems Framework are already applied everywhere in the world. The Responsible Innovation dimensions are deemed universal to innovation processes. Systems of Innovation is put in practice by researchers and governments all over the world to guide policy decisions. The Triple Helix has made its way into the developing world (Mutambi, 2011), after having proven its use in established innovation systems, covering every institution. The Quadruple/Quintuple Helix is even specifically designed for global sustainability problems. (Carayannis and Rakhmatullin, 2014) Open Innovation is widely adopted by firms and is connected to all kinds of sectors, even the likes of psychology. This makes it difficult to pinpoint areas where the framework could not be applied. Perhaps only in areas of conflict or countries with dictatorship the framework might not be useful, because methods of valid data collection will be virtually impossible, due to a lack of freedom of speech and fear of sharing honest opinions. Still, the combination of Quadruple Helix and Open Innovation is even suggested for models of international cooperation. (Casaramona et al., 2015) Especially if can be argued that we are living in a global civil society (Castells, 2008), the framework might be globally applied to any country with the privilege of civilisation, freedom and rights, where democratisation of knowledge is achieved or can be achieved.

To prove this, more research needs to be done and other relevant intersections of innovation systems can be examined in order to gather more evidence for developing responsible innovation systems. The following sub sections consider those intersections were it is most likely that lessons can be learned, or the system would be in need of a responsible innovation system.

8.4.1. Population (sectoral) generalisation

The population that has been targeted with this thesis project can be defined as any stakeholder in the Indian rural energy technology innovation system. The focus for developing responsible innovation systems can therefore be easily shifted towards other segments of that population, or rather other sectoral innovation systems in India.

As was seen in 8.3, the measurements of triple helix collaborations can be done in any type of sector where knowledge creation is happening, evaluated on the number of publications on subjects. It is likely that adding an institutional sphere of civil society to this, will still have the possibility of assessing collaborations. However, other types of indicators must be sought, because it was found that the civil society in rural energy technology creates relatively little explicit knowledge (like publications are), due to a weak contribution to the knowledge space. Better indicators of tacit knowledge, or social capital in general, could be helpful to discover quantifiable relations to the civil society sphere for more sectors.

It could also be interesting to assess each component of rural energy technology in itself, to discover which component is acting as a barrier to attain responsibility. For example, the energy storage, information technology, electrical engineering and solar energy sub sectors could be separately addressed to make it fully visible where responsibility should be improved in order for rural energy technology to thrive. At the same time, the rural energy sector is part of the larger energy sector, making a larger scale analysis of the responsibility of that system possible as well.

8.4.2. Location generalisation

Apart from different contexts within India, other contexts across the globe might appear as suitable cases to asses and guide in responsibility. As was explained in the introduction of this section, the

framework can potentially be applied universally around the globe, where democratic knowledge societies are present with freedom of speech. However, to remain close to the initial context of India, several countries might be considered that have similar characteristics.

The Electricity Governance Initiative (EGI) appeared to have this same idea, since it set up a programme in 2003 for worldwide guidance of electricity governance. It is led by the World Resources Institute and Prayas Energy Group and funded by parties like Shakti Foundation, USAID and the Netherlands ministry of foreign affairs. A global trend has been the unbundling and privatisation of electricity sectors, just as happened in India. The EGI was motivated by the concern that this unbundling and privatisation would capture policy and regulatory processes and crowd out public interests. EGI works with a coalition of civil society organisations and research institutions to engage with governmental institutes in discussions around creating the right governance structures for a better world. Tools were created that can help build the capacity of local civil society actors to asses and influence policy structures. Feedback from partners have been positive, saying that *'the EGI reports were the first step in the right direction for openness in the power sector governance and engagement of civil society organisations in the process'*.

A total of ten countries have been part of the EGI projects, namely: India, Brazil, Indonesia, Kyrgyzstan, Mongolia, Pakistan, The Philippines, South Africa, Tajikistan and Thailand. It appears that the challenges that the power sector in India is facing, like lack of public participation, are being felt in the power sectors of those countries too. The countries were specifically selected because of their similarities, so that the tools of EGI could be applied to any of them. The Responsible Innovation Systems Framework could help expose many dynamics in a new light for those countries and could potentially help in opening up the policy making process. It is therefore advised for future research to do a similar project in these focus areas, where new insights might also lead to improvement of the framework and its further generalisation.

Especially the similarities with Brazil are noticeable. Information from the World Bank shows they are both federal republics, both ended up privatised, both are big countries with large wealth differences and large metropolises with a similar age breakdown. Both countries are known for corruption, both are a part of BRICS and are fast growing in GDP with a fast drop in poverty numbers. A large diversity in ethnic groups exists in both countries. (World Bank, 2015b) Also both lands were once colonised with the language of the coloniser remaining as the official language today. Finally, slums and favelas are essentially equal phenomena.

An important difference is the law that Brazil has installed that tries to foster innovation, by creating public investments and increasing government-industry-university partnerships. (Di Blase Parente, 2016) It would be interesting to evaluate the influence such a law has had on inter-institutional collaboration by using the Responsible Innovation System framework with its evolutionary principles.

It would also serve to do an analysis of a country that might show to be behaving responsibly. Insights in what country could be taken as a case for such a research were gained from the India Smart Grid Week, where the Canada workshop was attended. It appeared India and Canada have several similarities.

Canada also has many remote communities and are dealing with very high generation levels of renewable energy. Many people are going (partly) off-grid, due to the economic benefits. Thus, microgrid clustering is being done, solar home systems, smart meters, all this is requiring many technologies that are being researched for the case of rural India too. Similar to India with its states, the Canadian government works provincial governments. According to Joseph Ayoub, a speaker at the workshop, the role of the government in Canada is that of a facilitator of collaborations in growing smart grid activities. Therefore, it has set itself up as a platform for sharing ideas, raising awareness, learning, analysing and applying. The government is an active enabler of collaborations between universities and provides information for the business sector by qualifying and quantifying data for stakeholders. A clear Triple Helix structure.

A question was asked to mister Ayoub: *'You were talking about the Government being a facilitator for collaborations and a platform for idea sharing, is there some sort of framework that is used for this and is there also inclusion of the public?'* His answer: *'The industry inclusion and university inclusion comes from the requirement within policy that there should be government funded applied science, instead of theoretical, fostering industry inclusion. Several projects are including customers, however*

it depends on the nature.' It is clear that the government has forced itself, through policy, to be of an inclusive nature. It hints towards structural signs of an inclusive innovation system, which is the first requirement before anticipation, reflexivity and responsiveness can be applied on a systemic level.

Another speaker exposed more signs of responsibility in Canada. Alex Bettencourt, head of Smart Grid Canada, gave an insight in how the Canadian smart grid market has united itself in becoming more productive. He provided some interesting lessons that are relevant for the Indian market too. The association of Smart Grid Canada consists of mostly utilities and universities. Since utilities are all state owned, this is a strong University/Government mix. He was proud to mention that the total mix of energy in Canada is 70% renewable energy. Some critical issues were mentioned were he said that the vision of government and regulators are aligned with other stakeholders from the beginning, so that design choices can be made with governmental support. Demand response was included to bring in customers in the equation as well.

All these activities relate to the responsibility of the Canadian power sector and hints towards a potential accordance if such an assessment would be done with the Responsible Innovation Systems Framework. Research on Canada could therefore help in building the framework up from more empirical evidence of a success case.

8.4.3. Temporal generalisation

The generalisation in time. Is the framework still relevant in the coming future? Can scenarios be found, where this would not be the case? The anticipation dimension is hereby triggered, adding to the responsibility of this study.

Again, the evolutionary nature of the framework, that is the influence of helix theory, makes it that different settings and moments in time are accounted for and expected. The framework becomes relevant in the initial genesis stage, where creating the idea for a new regional development model is done. From that point on, any setting is accounted for, where any institution might be strong, weak or in between and the functional spaces knowledge, innovation and consensus are dynamically evolving and influencing each other.

However, apart from conflict, war or other parts where freedom of speech is not prevailing, there is a setting that can make the framework lose its relevance. This is at the time that another institution emerges and needs to be accounted for in innovation decisions. Arguably, this moment has already come. The institution of our ecological world is increasingly becoming important to consider, if humanity wishes to be in balance with the planet it lives in. There is a consensus in the scientific world that time is of the essence to integrate the loss of natural capital in the current models of cooperation, because the rate at which the environment is being altered is endangering humanity's own existence, or at least its peaceful existence. Already, the Quintuple Helix model was created by Carayannis et al. (2012), specifically to address an issue such a global warming through a lens of innovation. It is highly advised for further research to expand the Quadruple helix towards a Quintuple helix, so that environmental issues can be accounted for to and the values of our mother earth are incorporated in innovative products and processes, however, more on this in the recommendations.

8.5. Summary of the validation and generalisation

This chapter aimed to answer the question: *'What are the threats to internal and external validity of the research and what does this imply for further research?'*. With the help of a legitimation model by Onwuegbuzie and Leech (2007), several types of validity could be determined and evaluated. Threats to internal and external validity are examined this way, where generalisation is part of the external, but separately discussed. The amount of different validity types was extensive and shall be shortly recapped here.

The variation of data inputs, the presence of an interpreter during the semi-structured interviews, the consultation of public data sources to check responses for truthfulness, the creation of a communication strategy through the socio-technical value map and the flexibility of the theoretical framework itself have managed to remove several threats to validity. However, some issues could still be discovered that require addressing. Figure 8.4 shows which types of validity have been considered a potential threat, which ones have been deemed secure and which could not be determined or were irrelevant. The most important ones will be taken along towards the limitations and recommendations at the end of

this report.

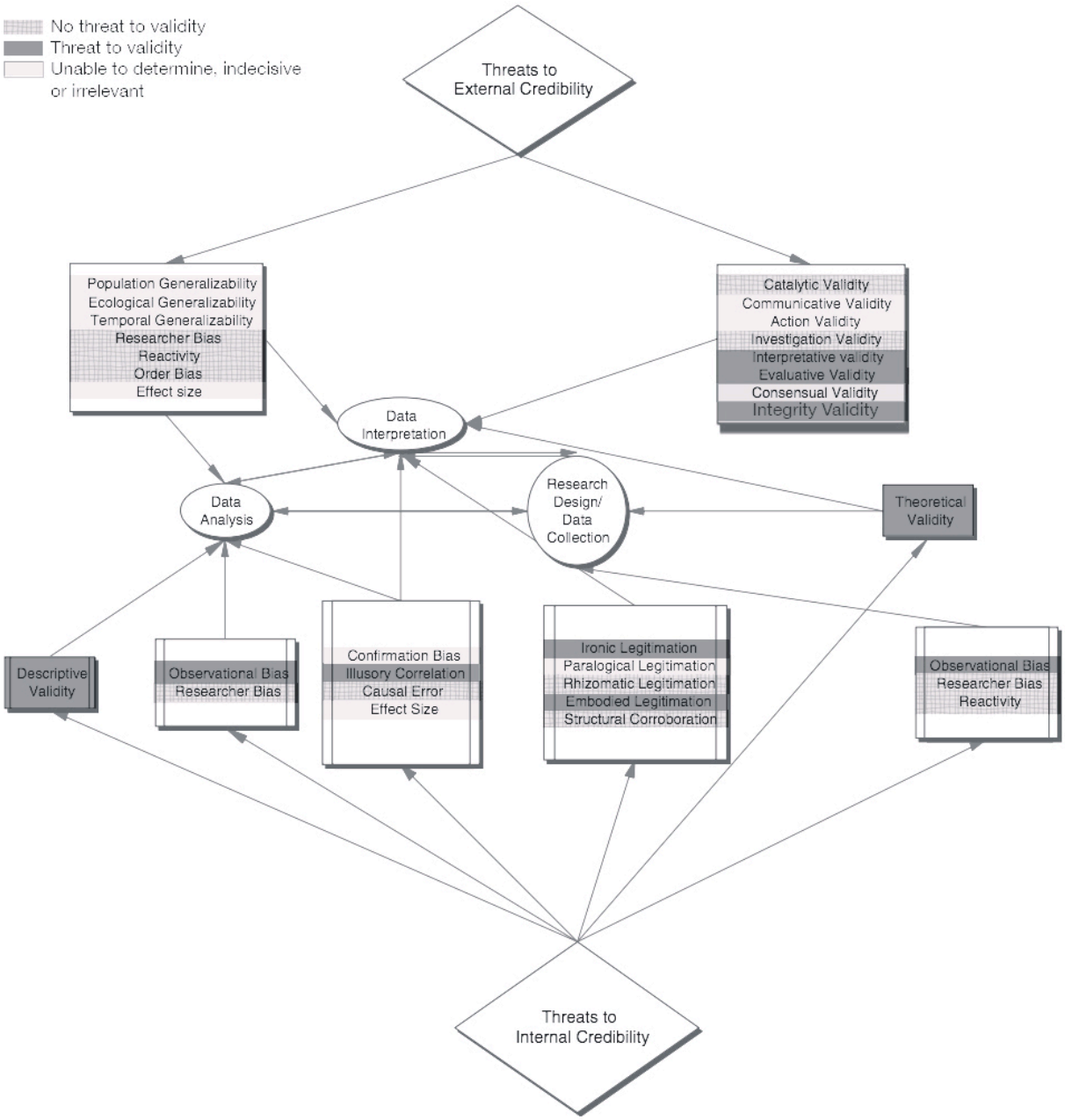


Figure 8.4: Discovered threats to validity from the Qualitative Legitimation Model (Onwuegbuzie and Leech, 2007), with and addition of Integrity Validity

Starting with the threats to internal validity. The dimensions of anticipation, reflexivity and responsiveness appear to be have been poorly described, resulting in unclear questions asked to participants. This lack of proper definition and description could also have led to illusory correlations or confirmation bias, where evidence for those RI dimensions needed to be sought in vague answers of participants. The categorisation of actors in institutions and their intersections can also have led to a threat in descriptive validity, since very different actors are now sometimes positioned in same group. Furthermore, a research bias might be present, due to the strong relations of the researcher with one of the participants. Also observational bias might have been created through a very selective sample size in the structured

interviews, promoting mostly the institutions of industry and civil society. Observational bias could also be present in the field visits due to a very small sample size, where each technology class was only interviewed once, creating potential illusory correlations as well. Another threat is the lack of knowledge of the Indian context that the researcher seems to have, questioning his ability to derive valid results from the Indian context for this task. Finally, the abstract thought experiments of ironic and rhizomatic legitimation have opened up the possibility of the existence of opposite explanations within the same context, where other intersections of the system might present other results.

For external validity some things can be noted too. Again the interpreter helped to assure interpretive validity, as did the socio-technical value map. Catalytic validity can be predicted, because of the clear gap in theory that is addressed an the overall focus to give participants something valuable. Investigative validity appears to be secured due to the strong moral compass of a responsible contribution and quality controls on data wherever possible. Finally, consensual validity can be reached, since other research finds similar results for a somewhat wider scope and with another methodology.

However, there are still certain aspects that threaten the results. Answering untruthfully, incompletely or wrongly due to lack of trust, lack of openness, hasty completion or misinterpretations of upfront information posed a serious threat to interpretive, evaluative and integrity validity, of which the latter is an addition to the legitimation model. Still, due to the strong quality controls, much information could be found apart from the data from the questionnaire. Finally, some types of validity in the legitimation model require further steps to be reached, such as action and communicative validity and also consensual and catalytic validity, which are suggested to further examine in subsequent research.

The generalisation can be separately described, but only that of the Responsible Innovation Systems framework. The results cannot be generalised, since in the internal validity it was shown that within the same context already different results might be found.

It appears that the framework might be globally applied to any country with the privilege of freedom of speech and the democratisation of knowledge can be achieved, because of the widely applicable theories on which the framework is built. However, to really prove that, more intersections of populations, locations and time settings must be analysed. For population (sectoral) generalisation it is suggested to analyse the different classes and technologies that rural energy technology composes of with the same framework, to see what the barriers are for full responsibility. At the same time, a large scope analysis of the full energy sector can be done. In the location generalisation a number of countries have been appointed with similar institutional problems as India, through the EGI initiative. Also, Canada is mentioned, because that is a likely case-study where relative responsibility could be determined. Finally, in the temporal generalisation, it is argued that the time has come to extend the Quadruple Helix to the Quintuple Helix, since a challenge such as global warming can only be addressed by adding another institution in the form of the natural environment.

9

Limitations, Recommendations & Conclusion

In this chapter the threats to validity will be expressed in the form of limitations, from which several recommendations can be derived and conclusions can be drawn.

The limitations of the research, in Section 9.1, will describe what went wrong or could have been improved in this thesis project. Subsequently, recommendations are given. Recommendations for further research that will improve the theoretical approaches or practical methodologies in Section 9.2 and several recommendations that can be appointed to the several institutions of the innovation system for obtaining a more responsible innovation process in the future in Section 9.3. Lastly in Section 9.4, the definitive conclusions are given about the responsibility of the innovation system and the implications of the proposed framework.

9.1. Limitations

Several limitations can be ascribed to the project, that restrain the results to certain boundaries. Most limitations have spawned from Chapter 8.

Since the Responsible Innovation Systems framework is based on several theories, theoretical limitations of each theory also apply to the framework, wherever they do not counteract each other. From the theoretical validity, it was observed that insufficiently taking into account of intellectual property creates a problem. Whenever such a consideration remains absent, it will be impossible to meet the conditions to a responsible innovation system, because it can also be expected that mutual trust shall not be established, which in turn limits an open environment.

However, the most important empirical limitation, coming from the threat to embodied legitimation, is that the framework has not been able to mature yet, by an iterative process where it has been tested over several case studies. It is the foremost reason why conclusions on the actual responsibility of the system should be doubted, because it is only the first attempt to a case study, meaning no reviewing of the framework has been done by others.

Also, theoretically it is not possible to analyse components further than their specific institutional contributions as the quadruple helix ascribes. Not only was this a threat to theoretical validity, but also to descriptive validity. For example, a social impact investor and a social enterprise are different types of organisations, but have both been characterised as IP. This generalisation of actors limits the conclusions that can be drawn on their specific functions in the system, apart from contributions to a certain institution.

Furthermore, some actors are shown as GIPU, for example, because of their public mission statements. However, they can actually not be operational in some of the institutional spheres yet, misrepresenting the contributions to institutions in the system mapping. The institutional configuration should subsequently not be based on mission statements, but on actual activities.

The description of the dimensions of RI are also subject to certain limitations. In the proposing paper

of the RI dimensions by Stilgoe et al. (2013) it is already disclaimed that a broad definition of the dimensions is taken, but a more constraining one is required. However, the broad description was taken, because of potential different ways that the dimensions would prevail itself in India compared to more western contexts. The broad description appears to have been insufficient in generating questions that could expose all activities that potentially contribute to the dimensions, since several participants abstained from answering these questions. Furthermore, the quality of the contribution to the dimensions could not be considered. For example, any form of anticipation is now considered a binary yes or no, while nuances in the quality of anticipation activities might prevail. This potentially leads to a difference in the actual responsibility, however, that could not be evaluated.

Responsibility as a concept is further blurred by the uncertainty about what degree of responsibility is practically sufficient, desired or reachable. In the construction phase, a degree of 50% responsibility was found. It appears unlikely that ever a 100% score can be reached, which makes the score in itself a number that misses a clear weight to its meaning. It can only be evaluated with more scores from different contexts, how well the Indian context is performing compared to others.

For the other two phases of the collective innovation process, exploration and implementation, it is also questionable if full responsibility really is that responsible. A situation might be sketched, where a private rural project has inclusion of a university actor. Where in industry has a 'time is money' attitude, universities generally take more time with more intangible returns of invested time. The time a company must spend to cooperate with the university might prevent the project from running smoothly and being profitable, making it collapse in the end. In this case a more responsible approach would not have been the more effective one. It poses as a limitation that the tension between responsibility and effectiveness is unclear.

The phases of the collective innovation process themselves are also subject to some descriptive problems. It could well be that the collective innovation process contains more or different phases than the three observed, or another segmentation of them is needed. The phases come into existence solely from the observations in this research and helped by differentiating the data collection methods. The phases should be subject to reconsideration whenever an iteration of the case study is performed.

More problems arose while questioning participants, leading to questionable answers in the questionnaires, of which all relate to the exposed threats to external validity, such as interpretative, integrity and evaluative validity. Some are induced by internal validity, such as embodied legitimation and confirmation bias. Only limited face-to-face interviews were done, which is preferable when dealing with such complex subjects. Also, often the person who was explained the research in detail with a PowerPoint presentation, was not the person filling in the questionnaire, because of delegation to other employees. To ensure knowledge about the content, again a phone call had to be done with the newly appointed employee. However, often it was found that those employees were not capable enough in both language and prior knowledge to understand what the research was about or to even have the capacity to describe the full scope of operations of the organisation, because of a limited overview of activities. Through emails, a more thorough description was tried, that employees could read in their own tempo. Only again, problems arose here, because it does not appear to be an Indian custom to consider emails as a valid form of communication, because to response rate on these emails was very low. Multiple emails never received replies, resulting in a large time before questionnaires were filled in and possibly much information got lost in the process. Some organisations took as long as two months before questionnaires were finally send back, potentially diluting the meaning of many concepts introduced during the accompanying phone call much earlier.

These problems have resulted in the answers of the questionnaire to be incomplete, misinformed, misunderstood, not integer, or even completely absent. While much of the answers could be cross-examined with public information or removed from the results, several subjects are still questionable in terms of validity, due to unclear answers, posing certain limits to the conclusions. Especially in Part C of Questionniare Y on the knowledge flow between actors and Part D on anticipation, reflexivity and responsiveness are expected to suffer the most from this. In part C it appeared to be impossible to determine inbound and outbound knowledge flows, because of a lack of clear descriptions about the relations, making the contribution of Open Innovation in the results of the construction phase very limited and true knowledge flow mapping to be impossible, apart from some individual considerations, as for example with CLEAN. Furthermore, in part D the results on the degree of Responsibility and the Consensus Space, might be corrupted, due to the inability of subtracting a perspective on the activities

that might contribute to anticipation, reflexivity and responsiveness, relating to evaluative validity and confirmation bias.

The limitation in time for performing this project is also clearly something that should be considered. A fully operational innovation system can never be assessed by one person in the short time span of 3 months field research. It has led to the absence of sufficient government agencies and universities in the participants, creating a bias towards representing industry and civil society, due to the majority of participants being social enterprises. The need for a broader exploration of the system was also clear from the rhizomatic and ironic legitimations, where it became clear that other intersections of the system can exist and may contain contrary results, which is not actively searched for now.

Another limitation is the absence of a consideration of the natural environment. While the focus of technologies that were considered for the rural case all have a strong tendency towards renewable energy generation, this was not posed as a specific boundary to inclusion to the research. The smart meters in Bodhgaya, for example, presumably measure predominantly unsustainable forms of energy. The mentioning of the sustainable development goals in the introduction, however, do require this approach.

Arguably, responsibility should be extended to sustainability in resonance with nature, since an irresponsible attitude towards the planet earth might ultimately result in negative externalities for human kind. Global warming is the most important issue that presses as an argument for this view. The extension towards a quintuple helix might pose as an solvent for this limitation.

Lastly, the consideration of the conditions to a responsible innovation system is done fairly superficial. The condition of an intellectual property regime was already addressed, because of its appearance in the theoretical limitations as well. One of the conditions on absorptive capacity was left completely open, due to the insufficient information available. While a great deal could be said about the context of the system and therefore an indication could be given about the accordance of the other conditions, the question of this research was not to evaluate the conditions to responsibility, but responsibility itself. It is therefore, that the conclusions about the conditions to a responsible innovation system should be further evaluated, for which in next section certain recommendations are given.

9.2. Recommendations for further research

The limitations that have been mentioned, all give ground to further research that might resolve those limits. This section sees to the elaboration of such further research and poses potential question that might be asked and optional strategies that can be pursued in answering those questions. Some suggestions could become new research projects and some suggestions are meant to give potential improvements that this specific research can do to generate more useful outcomes.

Discovery of other intersections of the Indian innovation system

A clear limitation to the research was found to be that it can never have captured the complete system of actors that influence innovation on rural energy technology. From the threats to validity of observational bias, rhizomatic and ironic legitimation, it was clarified that the research has a clear emphasis on the Industry and Civil Society spheres, which influences the analysis of the components element of the framework. It might even be argued, that instead of answering the question on how responsible the complete innovation system is, it was only researched how responsible the Industry and Civil Society spheres are behaving. In order to come to a full conclusion on the responsibility of the system, the following research question might be pursued: *'How responsible are the Government and Academic institutional spheres of the Indian rural energy technology innovation system?* In Chapter 5 several actors of both institutions have been portrayed, that might be requested to participate in a study like the one in this research.

Furthermore, from the rhizomatic legitimation observations it was taken away that potentially more intersections of interacting system of actors exist within India. A great deal of intermediary actors have been exposed that might have their complete own ecosystems, much like CLEAN and Shakti Foundation have managed to become the spiders in the web of the partial system that was exposed by this research. It is recommended to interview other GIPU actors to determine more sub systems and their relative responsibility to the one found here. GIPU actors are expected to be the hubs where responsible sub

systems will emerge, because of their inclusion of all institutions in their mission statement. Eventually, a more coherent image of the system will reveal itself and a more decisive conclusion can be drawn on the responsibility of the entire system.

Lastly, the intersections can also surpass the boundaries on the technological characteristics, or specify on a certain aspect of it. Instead of the rural energy technology innovation system, the whole energy sector can be researched. This would serve to generalise the framework to a larger part of the population in the case of the energy sector as a whole. On the other hand, the rural energy technology innovation system might be segmented into the different technologies that make up this system, like storage technology, for example. It would to serve to determine which sub systems are acting as a barrier to reach responsibility of the larger system.

Defining and measuring responsibility

Several limitations to the concept of responsibility itself were discovered, caused by threats to validity by descriptive and theoretical shortcomings that eventually led to potential interpretation or evaluation mistakes and illusory correlations. The main question clearly calls for a framework to measure responsibility. However, to measure responsibility is still difficult, since it is not easily definable when a system reaches a responsible state. In this research, collective responsibility in the system was simply defined as accordance to inclusion in the components element of the framework, accordance to two-way knowledge flows in the relations element of the framework and accordance to contribution to the Knowledge, Innovation and Consensus Spaces. Accordance to contribution to the Consensus Space, however, can be subject to two suggestions for further research.

The first suggestion is on the result that the construction phase of the collective innovation process gave. A percentage could be generated that showed signs of anticipation, reflexivity and responsiveness in relations. This percentage, however, can falsely create an image for a responsibility score, where a 100% is immediately perceived as the maximum. It appears questionable if such a maximum score is reachable or even desirable. Therefore, the measure should not be the score in itself, but rather the comparison of scores between different contexts, since only then a weight can be applied to this score. How responsible the Indian innovation system is, can only be answered by comparing it to others.

Suitable contexts that could pose as comparisons for the Indian one, have been laid out in Section 8.4.2. The different countries that emerged from that discussion all have similar policy environments and active civil society organisations, as defined by the Electricity Governance Initiative. The question '*How responsible is the current innovation system of rural energy technology in ... ?*' should be reproduced in these countries. Also a country that is expected to be behaving more responsibly, as was argued Canada might be, should be subject to the question of how responsible the innovation system is. Such research would not only give meaning to the 'degree of responsibility', but would also serve to validate the framework to a further extend.

Before that, however, a more robust measurement of the separate dimensions is necessary. While the inclusion dimension is relatively easy to quantify with the components element of the framework led by the quadruple helix, the other three dimensions have been subject to various validity concerns. This has led to limitations on what can actually be said about contribution to each dimension. In this research, a simple 'yes', 'no' or 'some' was introduced for contributions to anticipation, reflexivity and responsiveness, which ultimately did not prove sufficient to describe the various activities that these dimensions can contain.

Further research should be done on the nuances in contribution to the dimensions, which would help define and measure responsibility at the same time. It should be considered how the dimensions are internally managed, but also how this specifically emerges in the interaction between actors. For example, communication to partners of an actor's anticipation on the future does not mean it is also aligned and consensus is formed. A suitable research question would be: *'How can different gradations of contribution to the Responsible Innovation dimensions of anticipation, reflexivity and responsiveness be established for use in the Responsible Innovation Systems framework?'*

Lastly, there is a potential tension between responsibility and effectiveness of activities. To become responsible might take significant resources from organisations, like time, money or occupation of workforce. If these resources are to high compared to the return that a certain degree of responsibility

will give, there is no incentive for organisations to pursue these activities. This same tension also exists in Open Innovation practices, as was earlier explained in Section 3.2.3, where it became clear that a semi-open structure is more beneficial to companies than a completely open structure (Michelfelder and Kratzer, 2013) and that short term results could be negative due to the increase of resources spend. (Faems et al., 2010) Could systemic responsibility, measured with the Responsible Innovation Systems framework which incorporates Open Innovation, also show these characteristics? Is 'semi-responsibility' more beneficial to organisations from a self-interest point of view? A suitable research question would become: *'How do systemic responsible innovation practices influence short and long term effectiveness of the operations of organisations?'*.

A suggestion to approach this question is to consider the different phases of the collective innovation process separately, as was done in this research too. It can be expected that responsibility, according to the constructed framework, is not desirable in every step of the process. For example, perhaps government inclusion is only effective in the exploration phase, while ineffective in the construction or implementation phases. However, before this can be done, there must be a clear definition of what effectiveness means for each participant, since each organisation has a different set of goals.

Improved characterisation of components

The characterisation of actors according to the quadruple helix in the components element of the framework has provided a general image on the distribution of the different types of capital that can be created. However, as the limitations showed from a threat to descriptive validity, this is an oversimplification of the actors in the system. Social enterprises have similarities to social impact investors in an institutional context, but they have vastly different functions in the system dynamics. In further research, the difference in these functions should be better understood. A research question can be: *'How can actors within institutional configurations be differentiated in the Responsible Innovation Systems framework?'*.

A suggestion for exploration to answering this question is to consider Functions of Innovation Systems by Hekkert et al. (2007). Rather than focusing on the structure of innovation systems, this framework focuses on the processes that an innovation system should contain. Figure 9.1 shows the separate functions and potential interactions between them, with A, B and C depicting the probable initial interactions that drive change (motors of change), according to the researchers.

If the example of the difference between social enterprises and social impact investors is retrieved, it becomes clear that the categorisation of these two types of actors is different in such a framework, compared to equal in the framework that was created in this research. Social enterprises will focus more on entrepreneurial activities, while social impact investors generally focus more on the allocation of resources in the form of funding.

It can be researched if each institution is sufficiently contributing to each function, revealing additional insights for their relative weakness or strength in the system. Moreover, it could generate additional insights to the more tangible conditions for a responsible innovation system, such as market orientated culture, supportive infrastructures and institutional entrepreneurs. It might even deliver additional information about responsiveness, through the function of allocation of resources, and anticipation, through the function of expectations.

Enabling conditions to a Responsible Innovation System

For a better consideration of the context of the rural energy technology innovation system in India, a set of conditions was set up in Section 4.2.5. It could be determined with the help of the Responsible Innovation Systems framework that the system cannot be considered responsible, because not all four dimensions of Responsible Innovation are mutually shared among stakeholders. Therefore, the other conditions also needed to be examined to discover the reasons why this is not the case. The discussion on the conditions was done in Section 7.4, which showed several areas that require improvement, before a responsible innovation system might emerge. In the validity Section 8.2, however, it was determined that the conclusions on the conditions could be subject to some illusory correlations and the arguments that are derived from this might need to be revised. It is therefore, that the analysis of the conditions is recommended to be redone. A suitable research question that might emerge from this is: *'How can the enabling conditions of the Responsible Innovations Systems framework be evaluated and what characteristics will see to their accordance for the emergence of a responsible innovation system?'*

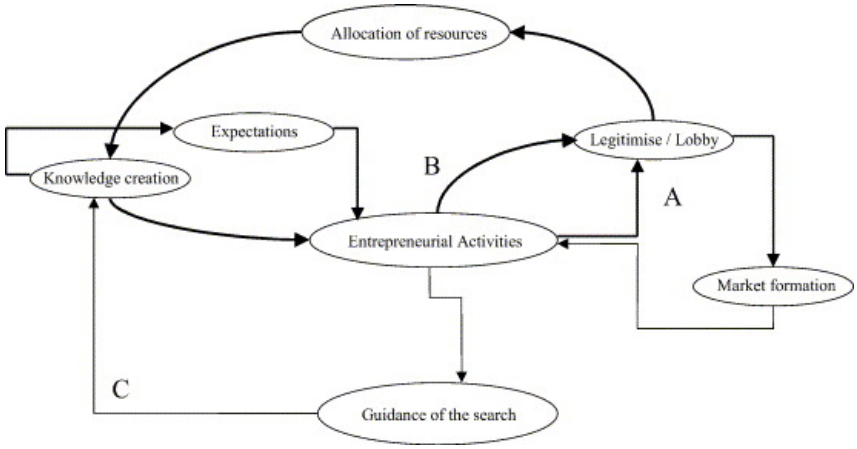


Figure 9.1: Functions of innovation systems, their potential interactions and motors of change (A, B, C)

Several suggestions to first attempts for reaching this can be noted. A total of 14 conditions were set up, but this chapter does not allow for all of them to be considered. Therefore, only the conditions of *'mutual trust and absorptive capacity'* will be reviewed.

The unwillingness of organisations to be open about their internal processes can be appointed to a sense of distrust. From the social-technical value map that was created to design a communication strategy with the Indian communities during the research, the lack of trust of Indians in each other and the institutions governing them appeared. This was again found in other research and in observations during the questionnaires, where trust levels in government especially were low. It appears that creating mutual trust between the various stakeholders is one of the most grandiose tasks that rural India requires. So why not inverse the question? Instead of creating trust, one could also remove the need for trust altogether.

A recently emerging technology promises to do just that. Blockchain technology allows for decentralised value transfer networks to be created, where the need for trust is eradicated. It can be researched how the introduction of a blockchain based energy infrastructure might ensure all different stakeholders of the innovation system to come together and operate on a platform of which they know that every party is forced to play by the rules that were agreed on. A deeper analysis of the question if Blockchain could serve to reduce energy poverty in rural India is portrayed in Appendix G.

Lastly, the condition of absorptive capacity could not be evaluated, due to limited information on the subject. Therefore, it is highly advised to conduct a separate research project that analyses the degree of absorptive capacity in participating organisations. A suitable research question would be: *'What is the degree of absorptive capacity in organisations active in the rural energy sector in India?'*. A potential strategy to answer this question might be derived from the earlier in Section 3.1.2 explained research by (Scholten and Van der Duin, 2015), especially because of their connection of absorptive capacity to responsible innovation practices.

Extension of the Quadruple into the Quintuple Helix

In Section 3.2.2 the extensions to multiple dimensions of the triple helix innovation model were presented, namely the Quadruple and the Quintuple Helix, of which the latter was not used in the Responsible Innovation Systems framework. The environment, nature, or rather, planet earth as a separate institution is what Carayannis et al. (2012) proposed for the Quintuple Helix. The necessity for such an addition becomes clear from global problems such as climate change, which was also emphasised in the temporal generalisation of Section 8.4.3. Such an institution would guide decision making in favour of solutions that are in alignment with the natural environment surrounding it, much like the triple helix needed to get in alignment with society surrounding it.

For this research, the addition of another dimension to the already complex framework was deliberately excluded, because appointing specific actors that act out of the interests of an intangible entity would be too complicated in the limited time. Still, it is a task worth investigating. It would not analyse

only the responsibility of a system, but surpasses to assess and guide on its sustainability in line with nature. It all lies in the research question: '*How can the Responsible Innovation Systems framework be extended with the Quintuple Helix?*'.

A challenge in this question is that there needs to be a clear definition of an actor contributing to the institutional sphere of environment. Who creates natural capital? An actor that is based out of single sphere pure natural capital creation can be nothing else but nature itself, right? An institutional actor analysis map as shown in Section 7.2.3 would give a completely unbalanced image, with only one single sphere natural capital creator, the earth itself. Potentially, the data collection methods used for applying the Responsible Innovation Systems framework would become instantly irrelevant for a framework extended with the Quintuple Helix.

Perhaps the question can be inverted. Not who 'creates', but who 'prevents from being destroyed' might be conceptualised. Multi-institutional actors can take over the role of natural capital creation by preventing 'negative natural capital creation', or 'destruction'. Some of the participants were keeping score of such prevented impact on natural capital. Data on litres of kerosene that were saved or CO_2 emission reductions have been logged by several of them. Simpa, for example, has even made this an integral part of their website, keeping track of the impact they have made. In a Quintuple Helix configuration of the components element of the framework, Simpa would change from an IP (Industry-Public/Civil Society) actor to INP (Industry-Nature-Public/Civil Society) actor.

This observation leads to the next challenge. What indicators or determinants can be used to analyse if any actor is creating, destroying or preventing to destroy natural capital and what is the definition of natural capital? Tons of CO_2 or litres of kerosene prevented are surely not the only determinants of a natural environment capital exchange system. Solar panels or batteries are made from scarce materials that need to be extracted from natural resources (Tao et al., 2011), for which potentially many landscapes are altered to an unrecognisable state. (SONG and ZHOU, 2001) Copper that is used for electricity lines is increasingly becoming scarce, meaning that lower value ores are mined with a higher requirement of energy for subtraction of the same amounts of copper. (Harmsen et al., 2013) This would mean that the energy efficiency of any renewable source will presumably go down in the future, reducing the decreased natural capital destruction over the total balance.

It might be clear that simply 'adding' the fifth helix of nature in the mix is not something that can be taken lightly. It requires substantial work on the definition of actors that create, destroy or prevent destruction of natural capital and the determinants of these are complex and uncluttered. It should be advised that a closer look is given to circular economy principles in order to find suitable determinants that might give rise to actors acting in the interest of the natural institution.

Operational recommendations

While several recommendations could be given on exploring the expansion of the framework and the areas of interest, also some operational components of the research can be improved. These are somewhat evident, but for the sake of complete contribution to reflexivity of the research should be considered, so that the limitations resulting from threats to validity are completely covered.

First, embodied legitimation showed that the knowledge base of the researcher might be subject to severe gaps, both on an academic level as well as a cultural level. This limitation can easily be emitted in a later project by repeating the same steps with a researcher that has the cultural and academic base that appeared to be missing here.

Second, though its influence is assumed small, researcher bias can be present due to a larger observational data input coming from Rural Spark, because of a stronger relationship compared to the other participants. A researcher without any ties to the network can replicate the research to see if this validity has had influence on the results. This also is the case for the confirmation bias, which could not be sufficiently determined. Confirmation bias can be measured through inter-reliability with other researchers performing the same project. Communicative validity could thereafter also be engaged in performing debates between those other researchers, where consensual validity might arise from.

Furthermore, a threat to interpretive validity was found, because many answers to the questionnaire used for data collection in the construction phase of the collective innovation process proved difficult to interpret, as the content was sometimes to complex for interviewees. There are two suggestions

possible to emit this limitation, that is to either simplify the terminology extensively, or take more time to educate the participants in the deeper meaning of the research.

Next, integrity validity proved a difficult threat, since it was found that answers were given that proved untruthful in a later stage. It is recommended to keep this in mind in later projects that interview stakeholders in similar contexts were mutual trust is low and no appropriate intellectual property regimes exist.

Lastly, the operation of effect sizing was not performed. It can be debated whether to evaluate the necessity of such an action, however, including it will complete the total validity framework as was proposed by Onwuegbuzie and Leech (2007).

Overview

Table 9.1 gives an overview of the suggested recommendations for further research. Next section, however, gives more recommendations for the system and the actors that operate in it.

Table 9.1: Overview of recommendations for further research

Category	Focus Area
Exploration of more intersections in the system	- Additional G, U & GIPU actors and their relations - Other parts of energy innovation system - Segments of rural energy technology
Defining and measuring responsibility	- Add more context measurements for scaling the degree of RI - Graduation in contributions to dimensions of RI - Tension between effectiveness and responsibility
Improving characteristics of components	- Differentiate similar institutional actors according to functions
Enabling conditions to RI system *..more conditions to be researched*	- Intellectual property regime in open knowledge environment - Blockchain for prevention of needing mutual trust - Degree of absorptive capacity of participants
Extension of framework with Quintuple Helix	- Challenge of conceptualising single sphere natural capital creation -Determinants of natural capital creation or prevention of destruction
Operational recommendations	-To reduce threats to embodied legitimation, research and confirmation bias and communicative, consensual, interpretative and integrity validity.

9.3. Recommendations for the system

After giving recommendation for further research, some suggestions can also be given to the institutional spheres that form the innovation system. As part of the introduction of this report, an ethical guideline was set up were the responsibility of the research itself had to be ensured. The deliverable of the research, which this report is, should therefore be of an inclusive nature, while contributing to anticipation, reflexivity and responsiveness. Therefore, this sub section addresses each institution and some intermediary actors and tries to anticipate, reflect and suggest potential responses for them, all coming from a perspective of taking actions toward creating a more responsible innovation system.

9.3.1. Government

The institution of Government in India (GoI) is the least examined institution during the research, because the agencies that were approached all remained fairly closed and unwilling to participate. Still, several observations could be done. It became clear during this research that within the boundaries of the institution of government, much is currently changing. Still, much is also left in need of change. Several suggestions to the GoI can be noted.

From Chapter 5 it was found that **there is strong evidence for misrepresentation, or manipulation, of data on electrification that is collected and publlished by the GoI**. Where along the long line towards government documentation this corruption is done is unclear, but the Rural Electrification Corporation (REC) needs to address this. It is expected that the confusing definition of an electrified village is influencing this corrupted data. The Niti Aayog (former Planning Commission) has recently acknowledged the problems surrounding the definition for electrification. On the 27th of June 2017, it released a draft version of the new National Energy Policy, where it not only promotes the activities around energy access to happen with more truthful numbers, but also makes the suggestion that could help solve the problem of the definition of electrification, quoting: *'There is also a need to redefine the concept of 'electrification', as occurs in the DDUGJY, to include stages of electrification in a village, with the village being deemed completely electrified if and only if ALL households of a village have an electricity connection, which witnesses reliable supply of electricity at least for a set number of hours.'* (Niti Aayog, 2017) It is suggested that policy makers take this addition of the Niti Aayog seriously and create robust monitoring activities around it.

Former suggestion might be a stepping stone to solving a deeper problem too, because during this research **levels of trust in Government were found to be low** across society. Other research has shown that especially in local contexts, trust in regional and national institutions is low. (Sriram, 2005) From the experiences of rural customers in this research, this low trust level can be explained. One of the visited villages was refused energy access simply for voting for the losing party in previous election. Creating a trustless environment with Blockchain technology, as suggested in the recommendations for further research of Section 9.2, is presumably not enough to regain a stable relationship. Government must improve itself in local contexts, so that corruption can be battled and trust levels can be restored.

In terms of responsibility of the system, another suggestion can be made to increase this from a Government perspective. Anticipation is positioned as one of the Responsible Innovation dimensions, and the Niti Aayog is the embodiment of anticipation in the government sphere. However, Niti Aayog was only found to connect with CLEAN in the exposed system. While CLEAN tries to represent the rural energy technology system, it has commented itself that this is not always happening sufficiently, due to low responses on their requests to members in their network. **The anticipatory function of Niti Aayog should be exploited more** by increasing knowledge flow from actors in the system towards the committee to include their views in the future vision that they create.

Another prevailing problem is the highly subsidised electricity price supplied by DISCOMs, that drains the financial reserves with every kWh sold and prevents private microgrids from emerging, reducing the acceleration of energy access for the population. (Comello et al., 2017) A way must be found to either raise the price of electricity, or reduce the amount of public kWh sold.

The lather is a solution that can be solved by creating decentralised generation and energy trading arenas, where the function of the DISCOM will not be to sell energy to the population, but to facilitate the infrastructure that is needed for people to sell their own energy, which they generate through decentralised solutions such as solar panels. It is essentially **the democratisation of the energy sector**, towards consumers becoming prosumers that can plug in to this dynamic system as they wish and sell their excess energy to the community. This way, the loss on every kWh is reduced and DISCOMs might become more financially stable, so that they can concentrate on providing infrastructure to those who have no access to energy yet. Two birds are hit with one stone, because government expenses will go down and civil society inclusion and empowerment will go up. However, this is clearly easier said then done, since is requires an organisational change for DISCOMs that might be prevented by incumbent power struggles. The **Energy Bazaar project**, explained in Appendix H is an attempt to democratise the energy sector, while creating incentives for consumers, prosumers, microgrid operators, DISCOMs and regulators. By using a blockchain infrastructure, combined with game-theoretical market models and grid optimisation algorithms, a platform is created for the dynamic smart grid of the future, which can be implemented in existing grids with smart metering. The project was founded on many of the insights in this report and should be considered an extension of the activities towards creating a responsible innovation system. Government agencies are requested to join the innovation processes which Energy Bazaar is setting out, so the a collective responsible innovation process will exist.

Other incumbent governmental agencies that are operating in the sector are the Rural Electrification Corporation (REC), Energy Regulatory Committees (ERCs) and State Nodal Agencies (SNAs), responsible for creating policies on national or regional scale and implementing them on a local scale. These agencies fulfil important roles in the system, however, it was seen that **few participants of this research directly connect to the REC, ERCs and SNAs and whenever these connections are present, they often cluster around a single participant**. This gave the impression of an unequal playing field, which was confirmed by participants that commented on government relations as 'only possible with friends in politics'. It is highly advised to the GoI to increase relations of their agencies with industry and civil society actors in the rural energy sector in a more equal manner, so that there can be sufficient political capital diffusion in the system, while also creating the communication and knowledge transfer channels for social and economic capital to diffuse in the governmental sphere. For example, the SNA could be included into the open innovation framework by Vrgovic et al. (2012) as seen in Figure 3.11, on which more in the suggestions for the industrial sphere.

Next suggestion lies in the observation of a weak Innovation Space. **The contribution to innovation is determined not to be sufficient from the governmental side, as suggested by the weak contribution of government to the Innovation Space.** It relates to the recommendation of expanding the framework with the Functions of Innovation Systems theory, whereas the function of entrepreneurial activities can shed a more detailed perspective of this observation. Whenever this is confirmed there to, it is clear that the GoI needs to improve its entrepreneurial activities and start projects where risk is taken in innovation practices. Recent work by Mazzucato (2015) advises a more entrepreneurial government, where she argues that risk-taking government agencies have nurtured almost all of the key technological innovations of the last hundred years. Especially on implementation of green technology, such as solar panels and other distributed energy generation solutions, she claims that such an attitude of government is desired. Therefore, the GoI should increase its entrepreneurial activities and contribute to the Innovation Space. A suggestion is to exploit one of the few innovations that could be found, being the project of OpenForge, where the GoI experiments with open governance. Also the introduction of a governmental research institute focused on (rural) energy technology, could help these processes.

9.3.2. Industry

With 14 of the 17 participants operating mainly in the institutional sphere of industry, a lot could be said on the subject. However, for individual recommendations, participants should consult the evaluation of ex-ante characteristics in Appendix D.1. This section will give a more generalised form of suggestions for the industry actors.

The first observation is that **the Idian rural energy technology industry sphere connects poorly to government and university spheres**. This means that political capital and human capital are also generally poorly diffused through the system, meaning that it is difficult for the participants to influence policy making and they might experience future difficulties in adding skilled personnel to their workforce. Also combined projects with government and university will increase contribution to the Innovation Space and accelerate responsible innovation decisions.

A suggestion for a strategy that Energy Service Companies (ESCOs) might pursue can be made with the help of an adjusted Open Innovation strategy framework from Vrgovic et al. (2012) as seen before in Section 3.2.3. Figure 9.2 shows the responsible innovation strategy framework, with all adjustments compared to the original in blue (light grey if BW). The exploration phase specifically includes all institutions, stressing the importance of having initial exploring activities that include all institutions. With these institutions activities on anticipation, reflexivity and responsiveness need to be done so that, for example, design challenges, possible conflicts and mutual goals can be derived and responsibility can be increased. The construction phase takes along the relevant institutional actors that were determined necessary for construction of the new product or service. Lastly, in the implementation phase, each institution is included again, so that it can be evaluated if the formed consensus at the beginning has been followed and monitoring of the product or service according to the requirements of each institution can be done.

However, this strategy needs to be evaluated with the recommended research on tensions between responsibility and effectiveness, as explained in former section. If it appears that effectiveness is not

increased by including all institutions in both the exploration and implementation phase, there is no economic reason for ESCOs to follow this strategy. It could be up to government to deliver subsidy in such events, to ensure that responsible innovation activities are followed in the collective innovation process. Also, anticipation, reflexivity and responsiveness activities might be spread over the various phases.

Also, this strategy requires ESCOs to have two-way communication channels with several partners, something that is scarcely observed in most of the participants in this research. It could be that an intellectual property regime for open knowledge environments, as discussed in former section, could serve to reduce the treats that companies perceive from sharing their knowledge.

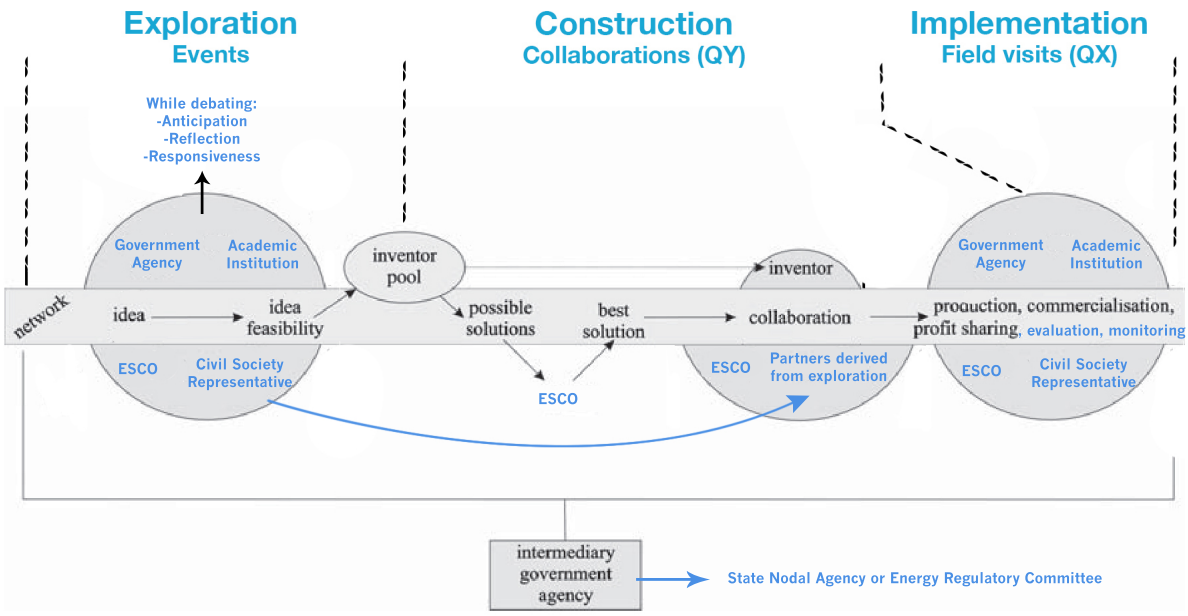


Figure 9.2: Potential strategy in pursuing a responsible collective innovation process from an ESCO perspective, as adapted from (Vrgovic et al., 2012)

9.3.3. Public/Civil Society

During the institutional analysis it was found that there are many actors that are fully or partly representing civil society within their mission statements. A large number of NGOs and social enterprises is found to be active, as well as research institutes that are focused on (energy) poverty reduction and publicly owned grameen (rural) banks. Still, several insights can be noted that can help the Civil Society sphere in improving their operations.

As described earlier, there exists a large distance between government and the population. While much of the responsibility lies with government, civil society needs to play its part too, in order to bridge this gap. Civil society actors need to get a seat at the policy making table, where they can represent the population and their demands.

To be able to articulate these demands in a more coherent way, there needs to be a larger contribution to the Knowledge Space from civil society actors, which was found to relatively weak compared to the other institutions. Research projects, possibly in combination with universities, could cover social sciences and make explicit knowledge on population characteristics available. One of these practices, for example, is the creation of social network analyses that can be used to better design community energy systems. Such a best practice might be discovered with one of the participants of this research.

Mrida, one of the participants of this research, explained during the held interview that before implementing any microgrid in a village, always a social network analysis is done in cooperation with universities.

From this analysis a Village Energy Committee (VEC) is formed, that will be taking care of operations and small maintanance of the microgrid. The feedback they receive is very positive and they have managed to develop villages way past energy systems only. From the community fund managed by the VEC, originally intended for investment in the microgrid, loans are provided to women in the village that are used for capacity development. For example, in one of the villages, sowing classes were organised, which resulted in a sowing company with which the village community is now generating extra income. Also, an entertainment centre could be created, in which educational movies on farming were presented, resulting in higher crop yields and other additional revenue streams.

VECs, as in this example, have not been observed much during this research, despite it clearly being part of policy explained in Section 5.2. It can therefore be suggested to civil society organisations to emphasise more on the creation of VECs, because the experience of Mrida and Vayam in this research has been immensely positive regarding the increased presence of responsible innovation activities, whenever such a committee was around. The VEC is at the same local level as panchayat raj structures. Mahatma Gandhi advocated panchayat raj as the foundation of India's political system. It would have been a decentralised form of government where each village would be responsible for its own affairs. Bringing the democratisation of energy towards villages this way, would be a revelation for the world of energy and the empowerment of rural communities.

Lastly, as one might recall from Section 3.2.2, the official term coined by Carayannis and Rakhmatullin (2014) for the civil society institution was the 'culture- and media-based public and civil society'. There has been, however, no evidence of any media that specialises in the reporting of the rural energy sector. It might be advised for the civil society sector to initiate such a media institute, perhaps in cooperation with the other institutions. This way information can be more freely distributed and delivered to members of the society that can benefit of an increased knowledge base on the rural energy technology subject.

Also, the cultural factor is not accounted for sufficiently yet in the definition of civil society. It is unclear what the opinions and views of the population from cultural perspectives are. The role of religion should not be underestimated in the design decisions. It might even be cautiously recommended to explore the institution of religion as a completely separate decision making environment in the helix structure. However, during the research there was no clear evidence of a strong importance on the forefront of religious believes, preventing the research from considering this. Still, it should be more deeper understood what the opinion of electricity and energy is from those perspectives, before responsible innovations can become robustly included in the society.

9.3.4. University

The last institution is that of the academic and educational worlds, where human capital is created. While the Indian academic sector was found to have the volume that is required to participate in a fully functioning innovation system, little evidence was discovered to argue that universities are operating in a responsible manner in cooperation with the participants of this research. Out of 17 universities in the exposed innovation system, only 7 were based in India and only 2 were technical universities. It seems that sufficient human capital diffusion is not being reached and future needs for employment of skilled workforce might be endangered.

Partly, this can be attributed to the observation that collaborations with Indian universities are not desirable for industry actors in economic terms. Research on Open Innovation has shown that it actually generates negative effects for Indian companies to use domestic scientific knowledge, whereas foreign scientific knowledge significantly increases performance. (Kafouros and Forsans, 2012) It explains the little found collaboration with national academic bodies and should pose as suggestion to Indian universities to examine the reason for this difference and solve the problems.

A potential solution might be the creation of incubators for university created technologies. Piconergy, one of the participants of this research, has been included to such an incubator that is managed by a university and several large industry players. These types of constructions are the perfect breeding ground for the emergence responsible innovation activities.

Also, following the lead of foreign universities, shared research projects might be pursued. These kinds of activities will contribute to the Knowledge and Innovation Spaces and should especially be combined with the civil society sphere to fill important gaps in the building blocks of a responsible

innovation system.

9.3.5. System as a Whole

While each institution needs to address its own issues separately, eventually systemic action is required. This sub section looks at the things the system as a whole needs to pursue in order to achieve a more responsible state. There is some overlap with the recommendations for the institutions, only now the reader is asked to view the matter in the light of the responsibility of the system, also including intermediaries. First, a look will be given to the actor in the system that appears to have taken the task of leading the system to a more responsible state. After that, for each element of the framework, the most important recommendation for the system is given. Lastly, some potential uses of the framework are given for actors in the system.

Guardian of the System

There is only one Indian organisation that has represented itself as the 'guardian of the system', meaning it positions itself as the coordinator of a responsible collective innovation process by being anticipatory, reflective and responsive, while including all institutional spheres and being solely devoted to energy access for the rural poor of the country. The CLean Energy Access Network (CLEAN) is this organisation. CLEAN is the result of a consensus forming between multiple organisations, among which Shakti Foundation, USAID, WWF and the German Development Commission (GIZ). After a round-the-table in 2013, the decision was made to constitute CLEAN with a specific task in the system that the founders thought was missing before. The mission of CLEAN is to be a network for everyone. Still young, being instigated in 2014, CLEAN is yet finding its way, but has already positioned itself as the main knowledge hub of the system on which the rural energy technology innovation system is relying. However, to further improve its activities, several things can be suggested.

The inbound knowledge transfer of CLEAN is too low compared to its outbound knowledge. ESCOs feel little urgency to interact with CLEAN and the mails that come monthly do not have the expected response. From Open Innovation theory in Figure 3.10, one sees that low inbound and large outbound knowledge combined with high centrality has likely significant negative consequences. CLEAN needs to create more inbound knowledge from the Industry and Public spheres, to fully take a benefit of their central position in the system. Within CLEAN, this inbound knowledge should then later be transferred to outbound knowledge for correspondence with the Government and Academic spheres. Ultimately, this process needs to be reversed as well, creating a virtual knowledge roundabout. Some techniques that could be sequenced are provided by the proposing paper on responsible innovation in the form of a set of tools. (Stilgoe et al., 2013) CLEAN inclusion in innovation processes should create a neutral ground where such activities can be performed.

In the words of Hellström (2003): *"Arenas of trustworthiness and informal joint authority created between a number of actors who may be involved in significantly creating, perceiving and transforming risk generating practices with respect to a technological system"*. It is up to CLEAN to provide this job and start bridging the gap between the institutions that is still existing, by providing the environment in which co-designing the next energy system for India can be nurtured. Such activities are explicitly envisioned by the Energy Bazaar project, explained in Appendix H, to which activities CLEAN is invited to participate towards designing decentralised energy markets.

Creating a Responsible Innovation System

The recommendations above were meant to create a more responsible innovation system, but it might be difficult to see where in the framework this is relevant. This section therefore tries to give the most important change that is required for the system from the Responsible Innovation Systems framework perspective.

In the **components element**, the Responsible Innovation dimension of inclusion is embodied. Inclusion between the institutions has not been found to be sufficient. Only the industry and civil society spheres seem to be merging sufficiently, looking at the great number of social enterprises active in the system. However, these social enterprises, do not structurally connect to human or political capital creating actors, such as universities and government bodies. Even an organisation like CLEAN, who has the objective to create human, political, economic and social capital, is not connecting well to all of them,

especially universities and government. Not only for sake of responsibility, should this be pursued, since it can also be observed that organisations who have better government connections are generally performing better in terms of impact they create. New actors in the system are advised to strive for including all institutions in at least the exploration phase, despite the larger amount of resources it will cost to bring together such a complex set of stakeholders, because it will create more sustainable innovation processes that generate more impact in the long term.

In the **relations element**, a more open innovation environment is required, especially in the construction phase. Due to lack of trust or conservative beliefs on keeping knowledge as a competitive advantage, organisations are reluctant to share a lot of information with their peers. Even between partners these issues have come up, as was observed in a collaboration between two participants in the research. While some have stated that they operate from an open-source ideology, it is up to the guardian of the system, namely CLEAN, to show the importance of collectively innovating. A more active knowledge sharing environment is needed, which might only be initially constructed at gatherings between stakeholders in the system. An important catalyst for this movement has to come in the form of intellectual property protection mechanisms, of which none of the participants have stated they work with.

In the exploration phase, the government public hearings need to rethink their openness too. It is virtually impossible to get feedback on the table of the regulatory committees and since the threshold in the current process is too high and even if it gets there, no evidence of it being used is provided. Government needs to rethink its position on how it is making policies and if it is taking into account the right actors. The role of local government bodies needs to be expanded in the data collection that governs policy making, while trust in their operations needs to be built.

In the **functions element**, the virtual spaces of Knowledge, Innovation and Consensus are required to form to a larger extend, where full responsibility can only be reached if the Consensus Space is exploited in the fullest by contributing activities to the dimensions of anticipation, reflexivity and responsiveness.

The Knowledge Space actually appears to be quite well-formed, but a closer look towards the institutions shows that civil society actors are not creating sufficient explicit knowledge. It is advised to NGOs and social enterprises to increase their R&D activities on social capital agenda points. This data can later be used in discussions on policy creation, business model implementation and community creation.

The Innovation Space showed that next to the civil society, government is not an active innovator. Hardly any project was found where the government takes the role of innovator together with others players in the system. This shows that in the creation of new products and services, sufficient political capital is lacking for it to become a robust intervention of the regime.

The Consensus Space is formed from activities on anticipation, reflexivity and responsiveness. How can the system enhance its contribution to this? For **anticipation**, India has an important actor, namely the Niti Aayog (the former Planning Commission). Niti Aayog is responsible for the long term visions of the government and influences policy on every section of the energy sector. In the system, CLEAN was the only one found to have a direct connection to the Niti Aayog. It might be advised for CLEAN to encourage the members in their network to take a close look on the future visions of the Niti Aayog and assist them in creating the future visions of their own organisations in alignment with the Niti Aayog reports. Currently, only feedback is asked from member organisations, which according to CLEAN itself is not happening as often as they would like. **Reflexivity** is somewhat harder to establish on a systemic level, because it requires a holistic view of the system in order to determine ones own position. Such holistic views are not found in any literature available, except in this report. It is, therefore, advised to all members of the system to take the overviews of the system that this reports sketches to heart, because only then a comprehensive understanding of the role division in the rural energy technology innovation system in the perspective of responsible innovation might become clear. **Responsiveness** has been seen in the results of Chapter 7 to be relatively in order. There is a stable funding environment, sufficient international influence and a strong focus on the rural energy technology sector from some influential partners. However, looking at the little inclusion of university and government in the found intersection of the system, a greater consideration of human capital is needed to supply the future workforce and political capital to fuel an ever changing environment with policies that can cope with a rapidly development technology.

Lastly, the evaluation of the**enabling conditions** to a responsible innovation system should be improved. The following conditions were not found to be in order: *Consensus on knowledge as the key to economic growth, process orientated knowledge management, intellectual property protection, a sense of competition, democracy in decision making, open environment, mutual trust, the presence of RI dimensions within and among actors in the system, competencies of universities in knowledge transfer and absorptive capacity*. Current evaluation of the conditions is taken from a broad intake of observations, but a detailed evaluation is missing. Therefore, it is advised that a separate research should delve deeper into the conditions and make separate reports on what can be done to improve. However, it is clear that these are problems that cannot be solved by individual actors alone, but need a systemic movement in the right direction.

As the guardian of the system, CLEAN should consider putting a task force on creating the right advocacy tools in order to get towards improving on the conditions. They need, for example, to play an active role in attracting university involvement, need to create intellectual property mechanisms that their members might benefit from while collaborating in the industry, educate their members on knowledge as a key driver of economic growth and strive for the alignment of the activities on anticipation, reflexivity and responsiveness. Without accordance to such conditions and a great effort of co-creation of solutions, a responsible innovation system will not emerge.

9.3.6. Using the Responsible Innovation Systems Framework

The use of the Responsible Innovation Systems Framework, which measures systemic responsibility, is not limited to research purposes only. On the contrary, it is meant for wide use across different institutions. While an early attempt at an indicator, the degree of systemic responsibility has the potential to become a tool for assessment. Its objective is to help decision making into the most mutual beneficial outcome for everyone. For a decision making entity, the degree of systemic responsibility can help to structure decision making processes both internally in the organisation as externally by observing a set of cooperating partners in the system.

How to measure one's own contribution to systemic responsibility? By evaluating internal processes according to each of the elements in the framework, the degree of systemic responsibility can be found. For the component element, the question may be asked: *'Do my partners include the institutions of government, university, industry and civil society and are we collectively creating political, human, economic and social capital?'*. For the relations element, the question may be asked: *'Does there exist two-way knowledge flow between me and my partners, where we exploit each others knowledge base to the fullest and in complete trust and honesty?'*. For the functions element, the question may asked: *'Is there knowledge creation and innovation with each of my partners and are there techniques to collectively anticipate on the future, reflect on roles or divisions and create resources for responsiveness, so that our activities might be aligned?'*. If, and only if, the answer to these questions all are confirmatory, your organisation has the maximum degree of systemic responsibility. Not only organisations might use these kinds of questions, but also events, policies, individual projects, strategic alliances, research, communities and advocacy groups might be evaluated according to these characteristics, however such claims can only be confirmed after extensive testing of the framework in such situations. It is therefore recommended to apply to framework extensively, until an exhaustive overview of potential applications for cooperative environments can be concluded.

How to measure the contribution to systemic responsibility of a complete system? Here, some difficulties emerge. This mostly relates to the observation in the validity Chapter 8, where it was found that within a single context, multiple realities can exist, because of the many intersections within the network of an innovation system. To fully measure a complete system's responsibility, an extensive project is required, evaluating the many actors on their partnership and activities separately. Above questions for individual organisations are therefore also relevant on this holistic scale. However a structured approach is necessary to assure a relevant sample group of the system to which these questions can be presented. It is therefore necessary to do an extensive contextual analysis of each of the institutions of the system, before the participants can be chosen. From each institution, the most important, influential and mature organisations should be included in a survey much like the one in this research. The persons answering the questionnaire, should be at high positions in the organisation, so

that a full scope of the organisational operations is present and can be communicated. This way the core activities of each institution are evaluated and the most comprehensive evaluation of the systemic responsibility will be possible. The reason why the responsibility of the innovation system of rural energy technology in India could not be given with confidence is exactly because not all institutions were sufficiently included in the participants. Still, intersections of the system can be used to generate initial observations, as has been done in this research. The fractal behaviour of the Quadruple Helix is therefore visible in the Responsible Innovation Systems framework, since it can be used on different scales within our societies.

The context analysis should also account for the enabling conditions to a responsible innovation system. Consensus is the opposite of conflict. To reach consensus and thereby the Consensus Spaces, one must prevent conflict. Therefore, any decision maker needs to be in the right context for conflict prevention to be possible. This is embodied in the enabling conditions for responsible innovation systems, explained in Section 4.2.5. Whenever the conditions are not met in accordance, organisations can try as hard as they want, but responsibility will presumably take more effort and resources than it will create benefits. Such conditions are most easily influenced by policy measures, emphasising the role of government in a responsible innovation system. Still, each organisation should strive to individually contribute as much as possible to these conditions. A responsible innovation system can only be constructed from individual actors contributing to its responsibility.

9.4. Conclusion

While 244 million Indians are still deprived of access to modern forms of energy, electrification is accelerating rapidly and those people are expected to become part of the energy system in the following years. With the decentralisation of modern energy technologies, such as solar power, the civil society population is more adapt to generate its own energy and becomes an integrate contributor to the system, where governments, industries and universities complete the set of institutions that influence design choices in the collective innovation process. It is increasingly important to design for inclusive approaches to innovation that incorporate the values of each institution, create anticipatory activities to future development in the system, enhance the internal and external reflexivity of actors and promote responsiveness to changing environments, so that collective irresponsibility can be removed and unfavourable outcomes of innovation will be prevented. This relates to the four dimensions of Responsible Innovation, being anticipation, inclusion, reflexivity and responsiveness, as defined by the literature. However, the literature did not define a framework for responsible innovation in innovation systems. Over the course of several chapters, each with its own methodology, it has been tried to create such a framework for assessing and guiding innovation systems on and towards responsibility of the collective innovation process. **First, these chapter shall be shortly summarised again.**

Chapter 3 has given a theoretical perspective of what it signifies to be a responsible innovation system, since this definition was lacking in the scientific literature. With the help of the theories of Responsible Innovation, Systems of Innovation, Triple/Quadruple Helix and Open Innovation, the definition of a responsible innovation system was set as follows: *A responsible innovation system is an open knowledge network that allows for the institutions of the Quadruple Helix to emerge and the regional innovation system to develop, while the dimensions of anticipation, reflexivity, inclusion and responsiveness are internally and mutually shared among the actors.*

In **Chapter** 4 this definition has been used to construct a framework that would allow for the responsibility of an innovation system to be assessed and guided. The framework consists of components, relations and functions. The components represent the inclusion dimension, by evaluating if all institutional configurations are included, defined by the quadruple helix to be government, industry, public/civil society and university and their intersections, respectively, creating political, economic, social and human capital. The relations have been guided by Open Innovation, describing the different types of knowledge, or 'capital', that travel across organisational boundaries, effectively creating two-way knowledge flows. The function of the framework became: '*responsible generation, diffusion and use of knowledge and innovation, which is realised through articulation of the Knowledge, Innovation and Consensus Spaces*'. The contribution to each of the spaces is determined, of which the Consensus Space forms when activities contributing to anticipation, reflexivity and responsiveness can be detected. In

addition, a set of conditions to the contextual characteristics were set up that need to be met before a responsible innovation system can emerge. The framework can be used in several parts of the collective innovation process, namely the exploration, construction and implementation phases.

Chapter 5 saw to an analysis of the contextual environment of the case study. First, rural energy technology was defined to be a combined term for small charging, solar lightning systems, solar home systems and various scales of electricity grids. Then, each institution of the quadruple helix is separately described according to its contribution to the rural energy technology sector, appointing the most important actors in that system.

Government has done many policy introductions, but with a deviating success rate. It was also found that the government data on electrification can not be considered completely truthful and that its relation with the public is not positively viewed everywhere. It defined Energy Regulatory Committees, State Nodal Agencies and the Rural Electrification Corporation as the most important actors.

The Indian population and its civil society was examined, exposing that the most energy deprived regions are Uttar Pradesh and Bihar. Also the amount of NGOs active in India appeared to be extensive, showing that there exists a strong movement within its population to drive change. However, most notably was a strong presence of social enterprises working on rural energy technology innovation.

Furthermore, the university sphere seems to be of enough capacity, however it was found that for industry their is no incentive to work together with Indian universities, since it draws resources, but does not deliver benefits. In the It already hinted towards a lack of inter-institutional relations, that prevents the system from being responsible.

Lastly, the industry sphere is mostly filled with multi-sphere social enterprises. The role of the Energy Service Company, as defined by governmental policies, is almost entirely being taken up by such organisations. They are the one closest to the rural population, which has led to the decision of making those social enterprise, on the intersection of the population and the industry, the first target for participants in this research.

An initial case study was designed in **Chapter**6, where the use of the framework could be tested for the first time. It is meant for data collection on the responsibility of the system. Three data collection methods were chosen, each representing a different phase of the collective. Four events were visited for a evaluation of the responsibility in the exploration phase. In the collaboration phase, a total of 17 participants, of which 13 social enterprises and 4 intermediaries, were asked for their characteristics, institutional positions, relations to other actors and responsible innovation activities in a structured interview. Lastly, five field visits were done to examine end users in rural areas with a semi-structured interview for the implementation phase.

The results coming from the case study are presented in **Chapter** 7. It gives an initial insight in what observations the use of the framework might give.

In the exploration phase, only one out of the four events could be considered fully responsible. Also this was a one-time event. Still, if the India Smart Grid Week would consider the institution of Civil Society to a better extend, it would also be considered responsible. It showed that arenas for responsible exploration activities exist in the system.

The construction phase, however, showed more significant gaps in responsibility, because little inclusion of government and universities in the components element is happening by the interviewed participants. The relations element could not be fully discovered, due to poor responses of participants. The functions element exposed that especially the Innovation Space is not properly enhanced by most institutions, while the degree of responsible relations was found to be 33% in the Consensus Space, showing which percentage of relations between actors contain activities that contribute to anticipation, reflexivity and responsiveness.

In the implementation phase, the semi-structured questionnaire exposed that not all visited projects could be considered responsible. However, whenever inclusion of the end users was done, the other three dimensions of responsible innovation started appearing as well, portraying inclusion as the gateway dimension for responsibility and making strong arguments for organisations to put time and resources into including the end users. Furthermore, an cautious evaluation of the enabling conditions to a responsible innovation system found that these are not sufficient to allow for a responsible innovation system to emerge. It urges for consensus on knowledge as the key to economic growth,

process orientated knowledge management, intellectual property protection, an increased sense of competition, more democracy in decision making, an open environment, mutual trust, the presence of Responsible Innovation dimensions within and among actors in the system, competencies of universities in knowledge transfer and increased absorptive capacity in the system and its actors.

The applicability of the framework seems most relevant in the exploration phase, because there were no operational difficulties and there does not appear to be a conflict between responsibility and the effectiveness of activities by actors in those phases, meaning that actors in the exploration phase do not need to spend significant larger amounts of resources in order to become responsible.

However, these observations needed to be evaluated on their truthfulness, leading the research to be validated and a generalised in **Chapter** 8, before the usefulness of the framework could be concluded. With a model for validation for qualitative studies, several validity threats appeared, such as on descriptive and theoretical grounds, as well as operational issues in the conduction of the research. The most important threat to validity to be mentioned here is the validity type of rhizomatic legitimation, which showed that multiple realities within the intersections of the innovation system can exist, which threatens the generalisability of the results coming from the framework.

For most validity threats, however, clear limitations were set up and recommendations could be made to improve and expand the framework in this **Chapter** 9. The exploration of more intersection of the system, the improvement of defining and measuring responsibility, the extension of characteristics in the components, the evaluation of the conditions and the inclusion of the natural environment as an extra institution are all topics that can help increase the validity of the results and the generalisability of the framework.

Also, a clear set of recommendations have been given for each institution, where they can anticipate on the future, reflect on their roles and increase their knowledge base for more responsive behaviour. It helped fulfilling the ethical guideline explained in the introduction of this research needing to be a responsible contribution itself as well. Furthermore, some recommendations for the system as whole were done, presenting CLEAN as the actor which should govern such processes. Lastly, some recommendations were done on the use of the framework itself.

With the combination of insights from these chapter, finally the main research can be answered: **How can a framework assess and guide the responsibility of the collective innovation process in innovation systems?**

How responsible the collective innovation process of an innovation system is, appeared difficult to determine. There need to be multiple 'scores' of responsibility in system that should be compared with. Also it is questionable if 'full' responsibility is desired, when it is taken into account that the required resources that need to be spend by organisation might put effectiveness of processes in danger. Therefore, more research is required, in the same context and others, before this question can be suitably answered.

The framework, however, seems to be a good first step towards the assessment and guidance of innovation systems on the systemic responsibility in the collective innovation process. Meaningful insights could be generated by separately assessing the desired configuration of the components, relations and functions of an innovation system on and its responsibility in different parts of the collective innovation process. With the insights from the case study, a large amount of recommendations for a more responsible approach could be formed, that will help in reaching the sustainable development goal explained in the introduction, showing the usefulness of the framework. Still, it is clear that the framework needs to mature significantly, before it can be confidently applied everywhere. All stakeholders of responsibility, which arguably is our complete society, are invited to build on from here, so that soon the world might benefit from the implementation of a globally connected network of responsible innovation systems. As the Indian proverb reads: *'Like the body that is made up of different limbs and organs, all mortal creatures exist depending upon one another.'*

A

Historical & Academic Perspectives on Innovation & Knowledge

Knowledge and innovation, two closely related concepts. Popadiuk and Choo showed that knowledge and innovation are indeed different concepts and how they relate. (Popadiuk and Choo, 2006) Throughout the years, many definitions of both concepts have come and gone. Knowledge is seen as 'justified true belief that inspires an individual to effective action' by Nonaka and Takeushi based on Huber. (Nonaka and Takeuchi, 1995)(Huber, 1991) Innovation was defined by Afuah as new knowledge incorporated in products, processes and services. (Afuah, 2003) Knowledge creation and transfer are therefore conditions for innovation. This section gives a historical perspective on how the literature of these

A.1. Knowledge Creation & Transfer

Naturally knowledge is a widespread phenomenon, with its own branch of theory in philosophy called epistemology. However, questions that were asked back in the days, differ tremendously from the questions about knowledge that are asked today, showing the change that the concept of knowledge has undergone. (Stroud, 2011) Whole books can be written about the subject, however, choices must be made. The most interesting segment of knowledge related to this thesis is knowledge in organisations, like governments or firms, and will be the focus of knowledge described here. There exist several ways to approach this type of knowledge. A review by Alavi and Leidner on concepts for knowledge in organisations has partly served as a source on this. (Alavi and Leidner, 2001)

A.1.1. Tacit, Explicit, Cultural Knowledge

One method is to differentiate three kinds of knowledge. Nonaka and Takeushi explored the ideas of tacit and explicit knowledge, whereas Choo put forth a third with 'cultural' knowledge. (Nonaka and Takeuchi, 1995) (Choo, 1996) Tacit knowledge is formed from experiences, creating beliefs and viewpoints, relating to know-how and skills that apply to certain situations. Explicit knowledge can be described as codified in words, formula's, models, documents, rules or procedures. It is the type of knowledge most easily transferred. Nonaka's foremost contribution was to show that explicit knowledge can be transformed into tacit knowledge and vice versa. This contradicted the original view on tacit knowledge by Polanyi from 1958. (Polanyi, 1958) According to Nonaki et al. in a following paper, true knowledge creation in organizations spawns from the constant knowledge conversion of tacit and explicit knowledge of individuals. (Nonaka et al., 1996) In Table A.1 the terms that are given to the four conversion types are given.

Table A.1: Knowledge conversion types (Nonaka et al., 1996)

from/to	**tacit**	**explicit**
tacit	socialisation	externalisation
explicit	internalisation	combination

Tacit knowledge is often connected to informal networks, as explicit knowledge is connected to formal networks. (Seufert et al., 1999) Both types of networks are expected to be encountered in inter-institutional collaboration. Communication with governments is, for example, more formal, while communicating with local media could pose more informal. Therefore both types of knowledge are important for this research. A thorough analysis of the communication between formal and informal networks was done by Kratzer et al., resulting in the finding that a misfit between these networks will decrease efficiency, but surprisingly increases effectiveness. (Kratzer et al., 2008) However, diving into the sociological effects as deep as this is not required for the objective of this research, which focuses more on a system approach. While tacit and explicit knowledge are more of an individual knowledge type, cultural knowledge, however, is more of a collective nature. It involves values and believes of social groups and their norms of communication, which in the strongly religious rural areas of India may prove an important factor.

Know-how, know-why, know-when, know-with

Other knowledge distinctions were done by Zack. A difference is made in procedural (know-how), causal (know-why), conditional (know-when), and relational (know-with) knowledge. (Zack, 1998) The reason these concepts are mentioned is their frequent appearance in the literature and should therefore be familiar.

Mode 1, 2 & 3

The final view on knowledge is that of the 'mode' concepts. Mode 1 and 2 were introduced by Gibbons et al. in 1994 in their controversial work 'New Knowledge Production' (Gibbons et al., 1994) It stated that knowledge, in the form of scientific, social and cultural, is undergoing a change in our modern societies.

Mode 1 is said to be basic university research, resonating from a time where push and pull, or linear, relations between knowledge were assumed. It starts with the discovery of a scientist that brings the discovery to a technology transfer office, which tries to find a market for it to get to an end user. (Siegel et al., 2004) (United States Office of Scientific Research and Development and Bush, 1945) Soon however, it became clear that knowledge does not only behave linearly. Among others, Büchel and Raub explained the importance of trans-disciplinary knowledge producing networks, serving as an argument for the earlier introduced Mode 2. (Büchel and Raub, 2002)

Mode 2 can be seen as the introduction to a more dynamic and socially distributed model of knowledge and a stepping stone to innovation processes. It does not pose as a replacement for Mode 1, but merely an addition. There are five characteristics that can be appointed to Mode 2:

1. Focus on application, rather than basic or fundamental research
2. Trans-disciplinarity, allowing communication structures between institutional organisations
3. Heterogeneous production of knowledge, in different types of organisations
4. Reflexivity, being able to handle different perspectives
5. Alternative quality control mechanisms, introducing more quality criteria

From 1994, 13495 citations were done of the work by Gibbons et al., according to Google Scholar, however, some research suggests weak spots in the model. Hessels and Van Lente exposed 7 returning shortcomings, categorised in 3 groups, with a systematic approach of the literature available on Mode 2. (Hessels and Van Lente, 2008) Questions are raised with the descriptive or empirical validity as the most common shortcoming. The original authors are accused of having a mistaken historical view and neglecting the diversity of science. Neither is their empirical evidence of the acceleration of three of the five characteristics of Mode 2, reflexivity, trans-disciplinarity and quality control. Also the theoretical and conceptual strength of Mode 2 is questionable, since the different characteristics show almost no harmonic behaviour. Some research responds very critically to the Mode 2, imputing it with claims of a political agenda. (Shinn, 2002) It must be said, however, that the application based focus and the heterogeneous aspects of Mode 2 are indeed returning phenomena compared to some of the models the are reviewed in this section. Also Mode 2 has succeeded in joining cognitive, organisational and societal research agendas, what can be explained as trans-disciplinary behaviour. While Mode 2 has

not proven to be the answer to all questions, it has opened up a dialogue for the further inclusion of disciplines in innovation studies.

Mode 3 is another extension that sees to adding more dimensions in order to explain knowledge and lays the ground for innovation on the scale of the knowledge society. It was introduced by Carayannis, Campbell and Davis in 2006. (Carayannis and Campbell, 2006) Explained by themselves: *'Mode 3' is based on a system-theoretic perspective of socio-economic, political, technological, and cultural trends and conditions that shape the co-evolution of knowledge with the "knowledge-based and knowledge-driven, gloCal economy and society"* (Carayannis and Campbell, 2009) In other words, Mode 3 allows for multiple knowledge paradigms of knowledge and innovation existing and interacting alongside each other, such as Mode 1 and 2. Carayannis argues that sustainable development requires a hybrid and trans-systemic thinking as is portrayed in Mode 3. Therefore, it is closely connected to systems theory, which will be further explored in 3.2.1 A key characteristic in Mode 3 is the formation of knowledge clusters and innovation networks in society. Knowledge clusters are formed by specific configurations of knowledge and knowledge types, unbound by geographic or sectoral boundaries. Innovation networks are meant to nurture interaction, connectivity and may be seen how clusters are tied together, showing the relationship between actors in the cluster. Other research by Parent et al. shows why this complicates the situation substantially. It seems that differences in knowledge transfer capacity of nodes in the network appear to be a possibility, which would determine the rate of knowledge transfer at the level of 'the weakest link' and therefore innovation. (Parent et al., 2007) This is but one of components of the dynamics that now come into play.

One can see the theory around knowledge becomes much more complex and requires understanding on several subjects. For the sake of simplicity, not a great level of detail will be given on Mode 3 here. Its importance for this research, and that of knowledge clusters and innovation networks, will show later on when the concept of innovation has been thoroughly described.

A.2. Innovation

The famous Greek philosopher Plato said: 'Necessity is the mother of invention'. It paints a simple picture of innovation, perhaps too simple. The motivations that spawn innovation can be more diverse. The Taj Mahal in Delhi required multiple innovation in order to be completed, all resulting from the grieve about the death of the loved one of emperor Shah Jahan, who ordered the construction. The Taj Mahal now rests as an iconic artifact of the Indian culture, which resonates with Callon's view of innovation as 'society in the making'. (Callon, 1987)

Figure A.1 shows the usual path of discoveries that determine the evolution of an innovation. The book 'The Myths of Innovation' by Scott Berkun frees the reader of the assumption that innovation just happens overnight. (Berkun, 2010) Most innovation requires years of work and in-depth knowledge in a field, before innovation can be done. Innovation is therefore never a one-time phenomenon. (Urabe et al., 1988) The great Apple innovator Steve Jobs was once asked how innovation is systematised. His

Figure A.1: Innovation Idea Tree Path (Berkun, 2010)

answer was: "You don't". (Berkun, 2010) Adam and Groves go along the same line, stating that in the case of innovation, past and present are not suitable measures for prediction of the future. (Adam and Groves, 2011) This makes subtracting logic from these paths an inconstant task and forces the results from this research to be met with question marks.

Still, this has not stopped scholars to explore the concept of innovation and find patterns and frameworks that can help to guide it. The theory of innovation is, much like knowledge, not based on a single 'school-of-thought', rather a mixture of concepts that date back to the midst of former century. (Twomey and Gaziulusoy, 2014) Parallel to knowledge transfer, innovation was also seen as a linear process. However, Soete and Freeman argued that old indicators of innovation output, often relating to R&D activities, are increasingly proving to be insufficient to measure innovation. (Freeman and Soete, 2009) In accordance, David and Foray have a broader view on innovation, claiming that it should less be seen as the discovery of new technological principles, but more in the exploitation of new combinations and uses of components from existing knowledge. (David and Foray, 1995) Cowan and Van Der Paal referred to this as "innovation without research". (Cowan and van de Paal, 2000) In the 1930s, Joseph Schumpeter opened the discussion on evolutionary economics, and today those ideas about dynamic and non-linear innovation are renewed. (Schumpeter, 1934) Arguably, the main contribution of Schumpeter was the understanding of capitalism being an evolutionary process of continuous innovation and creative destruction and he identified innovation as the main contributor to economic change. Soete and Freeman again, emphasised certain difficulties with these new views. (Freeman and Soete, 2009) Evaluation of results is difficult and sometimes misleading because of constant changing environments, preventing the differentiation of specific context variables from real causes and effects. Again, these claims stress the facts that successful innovation processes for one case are increasingly difficult to reproduce for another, where the context differs. It is therefore important to determine new performance indicators for innovation practises.

Before those indicators can be found, one must be aware of what is accomplished with innovation. Popadiuk and Choo differentiate several modes of innovation. (Popadiuk and Choo, 2006) While the modes presented seem incapable of including innovation as a dynamic process in society, they do make the valuable distinction between incremental and radical innovation. Incremental innovation is defined by the OECD as minor and insignificant changes in products and processes that do not involve a lot of novelty. (Statistical Office of the European Communities, 1997) Radical innovation is composed of fundamental alternations to a technology that open up new markets. The introduction of smart grids in the Indian society requires innovations of both kind, but it should be emphasised that the environment must be in the right conditions to allow these types of innovation to appear. A study by Koberg et al. has researched the conditions that are required for each type. (Koberg et al., 2003) It shows that incremental innovation is favoured by environmental dynamism, older and larger firms, younger CEOs and intrafirm linkages. Radical innovation on the other hand is favoured by environmental dynamism, inter-firm linkages, experimentation and the smooth and fast change in projects and products.

The environmental dynamism and inter-firm linkages indicators show that not only the internal characteristics are of importance, but also the external influences and connections, as was expected from the modern views on innovation. Lundvall argued, by taking a more systemic approach, that innovation happens through interactive learning, which is the acquisition of knowledge and competences through interactive collaboration between organisations. (Lundvall, 1992) Lienhard also argued in 2001 in his book that networks are just as important for innovation to succeed as other factors. Nowadays more than often, innovation processes cross institutional boundaries, requiring collaboration between science, industries and markets. (Avenel et al., 2007) (Elzen et al., 2004) In looking for a suitable approach that aims to guide a better innovation process for institutional actors, the incorporation of this multi-institutional approach should be a requirement.

B

Socialtechnical Value Map

This assignment was done as part of the graduation courses of the master Sustainable Energy Technology, which are meant to prepare for the thesis project itself. The quintuple helix, as explained in Section 3.2.2, is also part of this value analysis. The assignment has helped in creating a strategy for communication with stakeholders in the innovation system and is therefore relevant for this Appendix.

B.1. Introduction

Technology adoption in developed countries is hardly ever limited by the ability of the technology to perform its task. Mostly, the technology is not accepted by the public because it fails to address issues from the perspective of the public. A recent initiation by Greenpeace India, that installed a solar powered microgrid in a village in Bihar, did not get the response they expected. Daily-Mail (2014) In this particularly issue the public took the role of a protester, blocking the innovation.

The call for the need of responsible innovation that includes public values is rising. (Taebi et al., 2014) This abstract will try to address this need for the development of smart grid technologies in the region of Bihar, India.

B.2. Methodology

In order to assure a responsible innovation process, several methods are available to guide the process. (Stilgoe et al., 2013) (Owen et al., 2013) Von Schomberg (2012) (Friedman et al., 2002) Due to the limitations on size, it will not be thoroughly examined. Instead only the framework is presented that is used is to receive a socio-technical value perspective for smart grid technologies in Bihar, India. Rohracher introduced the sociotechnical value map (STVM) (Rohracher, 2002) which is composed of

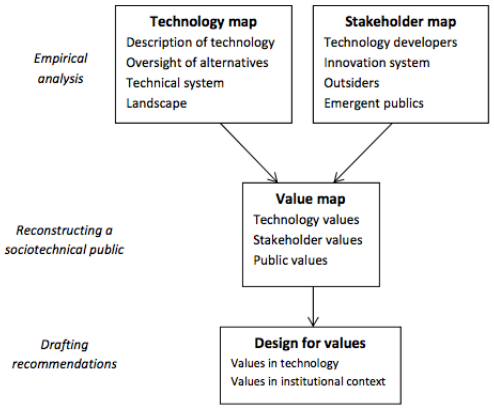


Figure B.1: STVM **?**

elements of Constructive Technology Assessment (CTA) (Rip et al., 1995) and Value Sensitive Design (VSD) Friedman et al. (2002) Figure B.1 shows how the STVM is constructed. Smart grid technology is still in development, which makes it suitable for STVM analysis, according to the requirements by Rohracher.

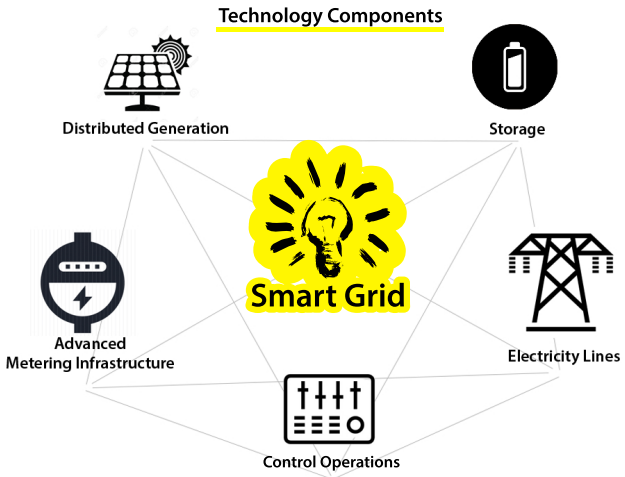


Figure B.2: Smart Grid Technology Components

B.3. Technology

Smart grid technology is composed of different disciplines. Figure B.2 shows a categorisation of the several technology regimes that can operate in a smart grid. Distributed generation, as an alternative to the conventional centralised generation such as coal or nuclear power plants, is generally composed of solar panels, wind turbines, biomass and small hydro power installations, or in other words, renewable energy technologies. The capacity share of renewable sources has risen from 9.4 MW in 2007 to 34.4 MW in 2015, which makes it the most successful smart grid component. (Tripathi et al., 2016) Apart from electricity lines, which are fairly straightforward, the rest of the technologies are still waiting for breakthroughs in the field, making them reverse salients of smart grid technology. Storage specifications are not yet economically viable for all solutions and will require some more time to develop. (Ozdemir et al., 2016) Advanced metering infrastructure is waiting for Internet of Things networks to fully emerge. (Chouikhi et al., 2013) Control operations are even more complicated, depending on the topology of the network and demand response techniques required to balance power levels. (Siano, 2014) It seems that the promised benefit of a smart grid, its highly interconnected and dynamic environment, also proves its weakness during the implementation phase, where interoperability between its components is difficult to establish.

The landscape that smart grid technology is operating in, heavily influences its design. Wealth is increasing and demand for electricity rises with it. This is putting a lot of stress on the electricity system. The Government of India (GoI) has been installing new policies for many years, acknowledging this problem. It has resulted in a vertically and horizontally unbundled electricity sector. (Salgotra and Verma, 2016) The electricity generation segment is living up to the targets that were set, however, electricity distribution is lacking in development, resulting in it being a reverse salient for the sector. (Pargal and Banerjee, 2014) There are more landscape characteristics that influence the introduction of smart grids. When prices of fossil fuels are low, centralised generation can be favourable. Prices of resources are of importance such as rare earth metals, used in batteries or solar panels and the increasingly expensive copper used in electricity lines. Also weather influences, such as heavy rainfall that increases hydro power or abundant sunny days to increase solar power. The nature of power grids, covering wide areas, being interconnected and dynamic, makes it that there are numerous external activities that influence the implementation of the technology. These are too many to cover in this small report, but is extensively done by Verbong in a multi-level analysis of the Dutch electricity system. (Verbong and Geels, 2007)

B.4. Stakeholders

Because of the extensive coverage of smart grid technologies, it is difficult to find a compact way of exposing stakeholders. In order to do this an innovation systems approach is used to identify important roles. The Quintuple Helix model (Carayannis and Campbell, 2012b) as a proposed extension to the Triple Helix (Etzkowitz et al., 1995) will serve as the base for the stakeholder analysis. Figure B.3 shows the innovation system according the model. For the region of Bihar, a stakeholder from each subsystem will be defined, assuming that, when all systems have a stakeholder that interacts with the rest of the system, sustainable development will follow. The emergent public is internalised in this system, due to the inclusion of the media- and culture-based public. Outsiders can be defined by by adding a spacial dimension, which the quintuple helix allows. (Leydesdorff, 2012) Because of the overlay of the technology on the society, one becomes more of an outsider when further away, following the proximity principle.

Political stakeholder; The GoI has appointed State Nodal Agencies to carry out the village electrification programmes in States and in the State of Bihar it is the BREDA organisation that is in charge of this. (BREDA, 2016) Academic stakeholder; The local university that teaches electrical engineering is considered, namely the Aryabhatta Knowledge University. (AKU, 2016) Economic stakeholder; Energy Service Companies (ESCOs) are responsible for the economic exploitation of the smart grids, defined by a draft microgrid policy. (MNRE, 2016) In this report we take Rural Spark. RS (2016) Natural system stakeholder; An organisation was found that sees to the interest of the natural capital of Bihar, which is the Centre for Environment Education. (CEE, 2016) Public stakeholder; The public can be represented by the Village Energy Committee (VEC), that will be democratically chosen by the population, as a draft policy on microgrids by the Government has proposed. (MNRE, 2016)

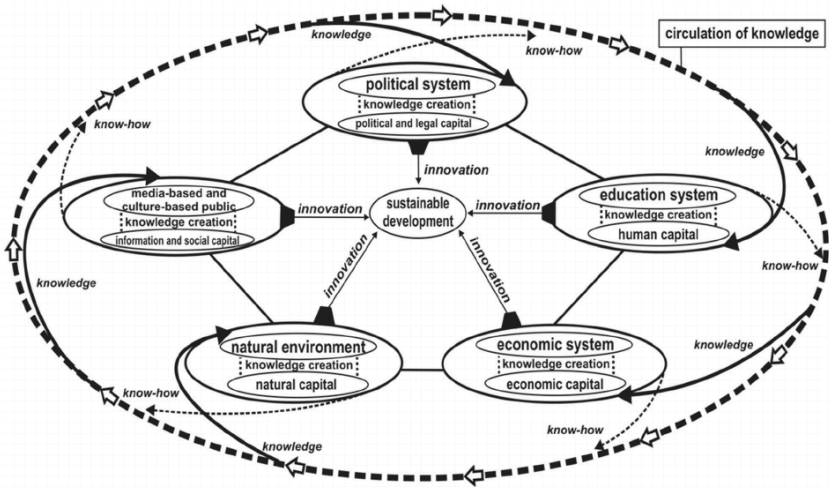


Figure B.3: Quintuple Helix Carayannis and Campbell (2012b)

B.5. Design for Values

To assure smart grid technology to be adopted, its incorporated values must be synchronised with them of the technology users, which in this case is the whole of society. It is assumed that values in Bihar represent general Indian Values. So what values bind the people of India?

A study on Indian values was done, that exposes numerous ways of thinking on different subjects. (Gopalan and Rivera, 1997) Three values are of interest when talking about smart grids. Firstly, the distrust and low empathy of people because of their views on human nature. When connecting your electricity system to your neighbours you want to trust them to handle it with care. Also when trading of energy comes into play. Secondly, the time orientation of Indians that explains the low planning culture is not favourable in the set-up of such a complex technical system as a smart grid. Thirdly, however, is the Indian view of the group before the individual, which does make a case for the adoption of smart grids.

How can be designed for these values? Blockchain technology will prove a valuable addition to smart grid technologies, since it allows for groups of people that do not trust each other to perform transactions and will make the trading system much less complicated, allowing for less planning needed, because of automation. (Mihaylov et al., 2014)

B.6. Discussion & Conclusion

Since smart grid technology is composed of many different disciplines and stakeholders in society, it is difficult to include all perspectives. It is even questioned if VSD, and therefore STVM, is even suitable for this technology. (Borning et al., 2004)

While the length of this abstract is nowhere near sufficient, it has exposed the technology, the stakeholders and their values for the region of Bihar, India. Especially the low degree of trust that Indians have of each other can prove a problem in setting up these networks. Blockchain technology can help solve this trust issue, assuring secure transactions in the network. Still, many problems and issues are facing smart grid technology adoption in India. Unfortunately the setup of this report did not allow for further deepening in these subjects and are therefore considered for further research possibilities.

C

Questionnaire Templates

Here the complete questionnaires are found. Questionnaire X is the list of questions there are used to guide the conversations in the villages. Questionnaire Y are the questions as directly asked to the companies and intermediaries.

C.1. Village Questionnaire X

1. How long have you had the product?
2. How was the decision made to go for this product?
3. Is there someone in the village that is responsible for contact with the makers of the product? Do you think they represent you as a customer?
4. Did you have any contact with the makers of the product?
5. Were you able to provide your preferences during the design of the product? Do have the feeling that your voice is heard?
6. Are the makers of the product often coming to evaluate the operations and your view on the product?
7. Did something ever happen that required that the makers of the product came and changed something about the product? Were you satisfied with their service?
8. Have you been visited by researchers from universities or governmental employees before and were they connected to the product makers?
9. Did any of the researchers, governments or product makers ask you for your future plans or said anything about what is going to happen in the future?
10. Would you like to know more about how the progress of the technology goes in the future?

C.2. Company/Intermediary Questionnaire Y

Questionnaire Y is divided in to five parts. Part A aims to uncover the ex-ante characteristics, as explained in Section 5.5. Part B is composed of questions that tell something about the institutional position of the organisation related to the framework constructed in Chapter 4 and some performance indicators. Part C goes deeper into the characteristics of the relations that the organisation is having. Part D relates to the Responsible Innovation dimensions and what activities of the organisation contribute to them. Part E asks for more information about the location of projects and if there would be a possibility to visit any.

C.2.1. A - Ex-Ante Characteristics

Firm size and age

- A1.1 When was the company founded
- A1.2 How many employees did the company have throughout the years?
- A1.3 What has been the yearly turnover

Credit

- A2.1 Has there been enough financial capital at hand and was this always this way?
- A2.2 What types of funding does the company collect? (seed, angel, VC, crowd, grants etc.)
- A2.3 Can the company already be profitable and self-sustaining?

Education and Human Capital

- A3.1 What level of education do the members of the board and the founders have?
- A3.2 What fields of study have they pursued?

Previous experience

- A4.1 If applicable, what was the former job position of members of the board and the founder(s)?
- A4.2 How long have the members of the board and the founder(s) been professionally active in the region of operation?
- A4.3 Was the your company a so called 'spin-off' of another company or university?

Innovation

- A5.1 Is there currently innovation going on in services or product development?
- A5.2 Was the motivation to start the company to make innovative products?

Motivation for starting the company

- A6.1 What was the main personal motivation of the founders for starting the company?
- A6.2 Was the founder(s) unemployed before starting the company?

Role of ethnicity

- A7.1 What nationality and cultural groups do the founder(s) and members of the board have or belong to?

C.2.2. B - Framework and Performance

- B1 Is your company a single- or multi-sphere institutional organisation?
- B2 What institution(s) does your company belong to?
- B3 Is the development on energy technology a main goal of the organisation, or does the initiative come from separate individuals within the company?
- B4 Is there any R&D happening internally in your company?
- B5 How many people has the company provided with any form of electricity throughout the years?
- B6 How has the cumulative installed capacity (in kWh) changed over the years?
- B7 What has been the reduction in CO2 or kerosine (if available)?

C.2.3. C - Relations

- C1 What kind of relation is there between the partner and your company?
- C2 When was the partnership and collaboration established?
- C3 How many contact moments are there monthly and has this changed?
- C4 Please describe the relation to the partner in terms of knowledge exchanges and techniques for getting to consensus on goals and expectations as are mentioned in the list of possible tools
- C5 Is the partner a single- or multi-sphere organisation?
- C6 What institutional sphere(s) does the partner belong to?
- C7 Is the partner doing any R&D activities?
- C8 Is the development on energy technology a main goal of the partner, or does it come from individuals within?
- C9 Is the partner based from India with their head office?

C.2.4. D - Responsible Innovation

- D1 What kind of activities were there performed to be able to anticipate future events and which partners are involved? Also mention how much this happens.
- D2 What kind of activities were there performed to be able to reflect on the own organization and the collaborations with the partners? Is this structurally reviewed? Also mention how much this happens.
- D3 Have all relevant stakeholders been included in the design process and at what stage in the proces and how are they selected?
- D4 What kind of activities were there performed to be able to response quickly to situations and which partners are involved in that? Also mention how much this happens.
- D5 How does your company tackle issues regarding intellectual property in collaborative innovation?
- D6 Were there moments in the past where a structural change within your company was required or performed?

C.2.5. E - Projects

- E1 Where are the projects located of your company
- E2 Would there be a possibility for Yvo to visit projects and talk to local customers about the experiences and perceptions on the products?

D

Results - Graphs and Tables

This section contains some of the tables and graphics that were deemed to large in respect to direct relevance, however might be consulted for some of the statements that have been done in the text.

D.1. A - Ex-Ante Characteristics - Results

As can be seen, part A has been fully filled in by ten ESCOs. Sometimes, however, public information was sufficient to include more of them. The intermediaries are not firms, therefore the ex-ante characteristics do not apply to them. It is now possible to start comparing ESCOs based on the ex-ante characteristics, so that a comparison between more similar ESCOs can generate more valid conclusions according to their RI activities. The original question about turnover has been eradicated from these results due to limited responses of participants.

D.1.1. Firm age

The age of participants is interesting in the question about the maturity of the system. From Table D.1 one might see that for a long time only DESI and SELCO were active in the market, but from 2008 other players started to come up. In the last five years the most newcomers have entered the market, of which Piconergy from 2015 is the youngest. This shows that the system is very young, with only about two mature companies. The 3 different age groups that have become prevalent are more easily comparable, since the ESCOs have had similar amounts of time to develop.

Table D.1: Starting years of ESCOs

Year	Organisation	Total
<2000	SELCO / DESI	2
2001-2005	-	0
2005-2010	Gram Oorja / Mera Goa Power / Mlinda / ONergy	4
2010-2015	Claro / Gram Power / Piconergy / Rural Spark / Vayam / Simpa / Mrida	7

D.1.2. Number of employees

The size of a company says something about the value of the work they are turning over and the impact it is making. Table D.2 divides the group in terms of numbers of employees. Most ESCOs have less then 25 employees, meaning they are most likely still in the startup phase. Gram Power and ONergy have managed to start expanding, whereas Claro is clearly growing rapidly. Since SELCO is the oldest company of the participants, their size could be expected. However the growth that Mera Goa Power and Simpa have gone through is worth noting.

D.1.3. Credit

A lack of credit is an often heard complaint of SMEs, and whether it is true or not, it is important to address to status of credit access. Table D.3 consists out of two parts. The first addresses if the ESCO

Table D.2: Number of employees in the ESCOs

Number of Employees	Organisation	Total
<25	Gram Oorja / Mlinda / Piconergy / Rural Spark / Vayam / Mrida	6
25-100	Gram Power / ONergy	2
100-250	Claro	1
250-500	Mera Goa Power / SELCO / Simpa	3

is in need of funds and if it is profitable. The second part shows of what type of credit their funding build up.

Only four ESCOs mention that they have sufficient funds, of which Mlinda is the only on who is not profitable, whereas ONergy is the only profitable ESCO that claims not to have sufficient funds. Gram Oorja, Gram Power and SELCO seem to have their credit issues well managed. All the other participants are both in need of funds and not yet profitable and therefore not sustainable.

The most popular are grants, which shows the importance of aid money in the system. Venture capital (equity) and debt are the other main credit types. Seed, angel, corporate social responsibility (CSR), crowd and self funding are all more or less equally apparent. What is noticeable is the large variety within the types of credit. There is not a single company that has exactly the same credit combination. This hints to the conclusion that there are at least sufficient types of credit channels available and companies looking for funds should evaluate other types of credit than they are used to.

Table D.3: Credit access of ESCOs

ESCO	Suff. funds?	Profitable?	Seed	Grant	Angel	VC	CSR	Debt	Crowd	Self
Gram Oorja	Yes	Yes			X					
Gram Power	Yes	Yes		X		X				
Mera Goa Power	No	No				X		X	X	
Mlinda	Yes	No		X		X		X	X	
ONergy	No	Yes	X	X					X	
Piconergy	No	No								X
Rural Spark	No	No	X	X	X			X		
SELCO	Yes	Yes				X	X	X		
Vayam	?	No		X						
Simpa	?	No		X		X		X		
Mrida	No	No					X			X

D.1.4. Human Capital

The competencies of the leaders of the companies is determined here, where the human capital of both the founders and the members of the board of directors is evaluated. Table D.4 gives an oversight on the fields of study and the experience that is present within the top level of the ESCOs. In the last column, for example, 10-30 signifies that the individual founders and members of the board have between ten and thirty years of experience. At least all founders and board members were found to have a minimum university level education, therefore this has not specifically been included in the second column, in which the frequent appearing MBA stands for Master Business Administration.

In general the ESCOs have a large and relevant amount of human capital indoors. Whatever is lacking in fields of study, often is made up in former job experiences. The most frequent profile was that of an MBA graduate with 20-25 years experience in banking. All of this shows that the system is in the hands of experienced professionals. Only Rural Spark and Piconergy stay far behind of the rest in terms of human capital, whereas they are both started soon after the founders had graduated.

D.1.5. Innovation & Motivation

Despite having the least human capital, Rural Spark and Piconergy do share a common attitude to innovation. The one has its own research department connected to Dutch universities and the other is part of an incubator in Mumbai that is part of an university. What is interesting to see is how the role of innovation is perceived in the ESCOs. Every company, except for Gram Oorja, is currently doing

Table D.4: Human capital of founders and members of the board

ESCO	Fields of study of founders and board	Former jobs and experience	Experience (years)
Gram Oorja	Management/ Engineering	Rural electrification/ Investment banking	10-30
Mera Goa Power	MBA/ Development studies/ Economics	(Micro)finance/ Project developer USAID	9-10
Mlinda	Law/ Management / MBA Cultural/ Engineering/ Sociology	Consulting/ Development/ Engineering	5-12
ONergy	Management/ Economics/ Marketing	General Electric/ Banking/ Creative	8-10
Piconergy	Environmental assesment/ Mechanical engineering	Student/ Project developer	2
Rural Spark	Industral Design/ Organisational/ Building Services	Students/ freelancing consulting	1-3
SELCO	Engineering/ MBA/ Policy	High positions NGO, Banks and Greenpeace, UN, World Bank	20-31
Vayam	(Rural) management/ Engineering/ MBA/Agriculture/ Economics	High positions in banks/NGOs/government	15-42
Simpa	Finance/ MBA/ Accounting/ IT	Banking/ Investment/ Micro-finance/ Technology	15-24
Mrida	MBA/ Engineering/ Marketing/ HR/ Finance	Technology/ Supply chain/ Customer service/ Quality control	8-32

innovation in any type of form, but only Gram Power and Mlinda were really started with a motivation to do innovation. The rest of the companies merely discovered that innovation is needed to reach their goals, that all relate to doing some form of social good.

SELCO gives a good representation of how the role of innovation was acknowledged in their organisation throughout the years. Before 2008 innovation was only done from need, but in 2008 a special innovation wing was started. Among other institutional side-streams of SELCO activity, like the political area, the innovation wing turned into a separate organisation in 2010, under the name of SELCO Foundation. The third mission statement on their website, quotes: "*Foster ecosystem development in the social sector through holistic thought processes in technology, finance, entrepreneurship and policy.*" SELCO therefore acknowledged the role of more independent research, something that the system clearly was needing at the time. The direct contact for the data of SELCO that is used in this research, was officially alleged to SELCO Foundation. It was only silly that there was no time to further investigate SELCO Foundation as a separate entity. In the visualisations of Part B in the next subsection, SELCO and SELCO Foundation are also depicted as two separate entities, with different institutional configurations. The first as a social enterprise and the other as a higher dimension of combinations.

At least Rural Spark, ONergy and Mrida have an operational knowledge creation department within their company and Piconergy is part of an incubator that partners with some of the biggest knowledge companies in the world. For some of the other companies their approach to innovation seems to be rather more out of necessity then the will to innovate, excepting of course Mlinda and Gram Power who are internally motivated by innovation.

A spin-off like that of SELCO foundation, has reversely happened with other participants. Those that have span off a mother organisation are Vayam and ONergy, respectively from BASIX and SwitchON.

D.1.6. Role of Ethnicity

So what are the ethnic backgrounds of the founders and/or members of the board within the ESCOs? Table D.5 shows how these is distributed among them. Most ESCOs are founded by Indians and have a full Indian board. Several have a mixed nationality within the company, mostly combined with USA citizens. Only Rural Spark consists fully of foreign citizens.

Table D.5: Ethnic backgrounds of founders and board members of ESCOs CHANGE ONERGY

Nationalities	Organisation	Total
Indian	DESI / Gram Oorja / ONergy / Piconergy / Vayam / Mrida	6
Mixed	Gram Power / Mera Goa Power / Mlinda / SELCO / Simpa	5
Foreign	Rural Spark	1

D.2. C - Relations - Results

This section contains the images that could be created as part of the results, but were not explicitly needed to be shown in the chapter itself, because it could be described shortly.

The first three graphs are the result of characteristics given to the components and partnerships in the questionnaire for the construction phase of the collective innovation process. Figure D.1 shows which organisations have their headquarters in India. Figure D.2 shows which organisation are solely focused on rural energy technology and which have multiple objectives. Figure D.3 shows which partnerships contain a funding element. Figure D.4 represents all actors that perform RD activities.

After that the tables are placed that show for each participant of the research the individual connections that contribute to the Knowledge and Innovation Spaces in Table D.6 and Table D.7.

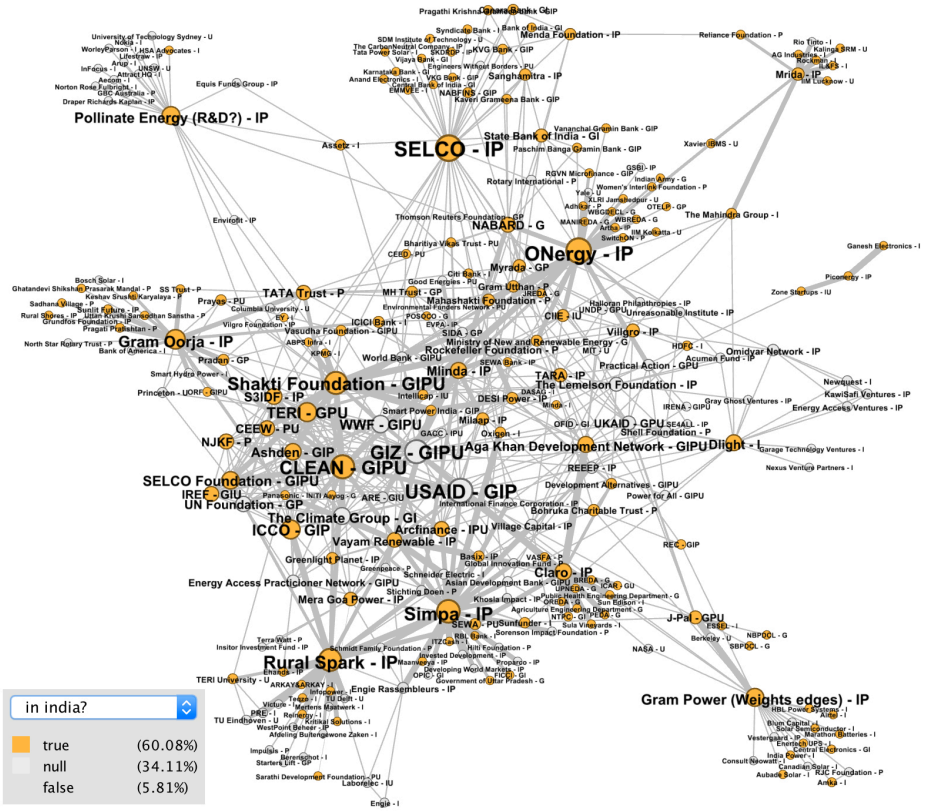


Figure D.1: In orange the organisations with their HQ in India; Grey are foreign organisation

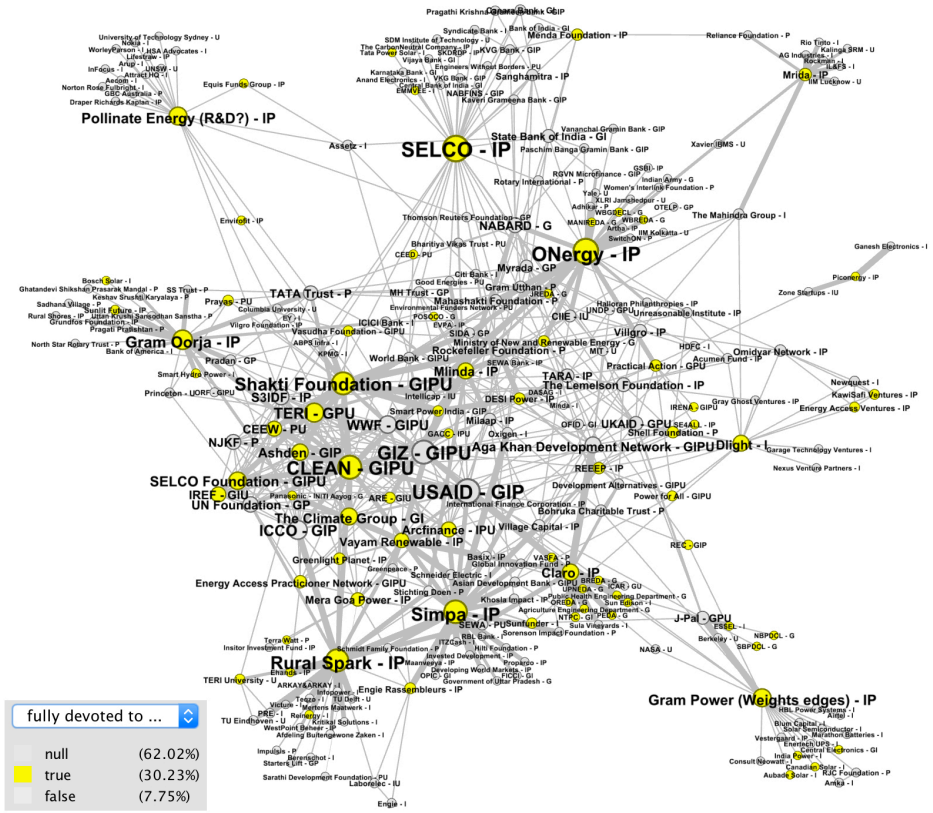


Figure D.2: In yellow the organisation that are devoted to energy access; Grey organisation have multiple or other agendas

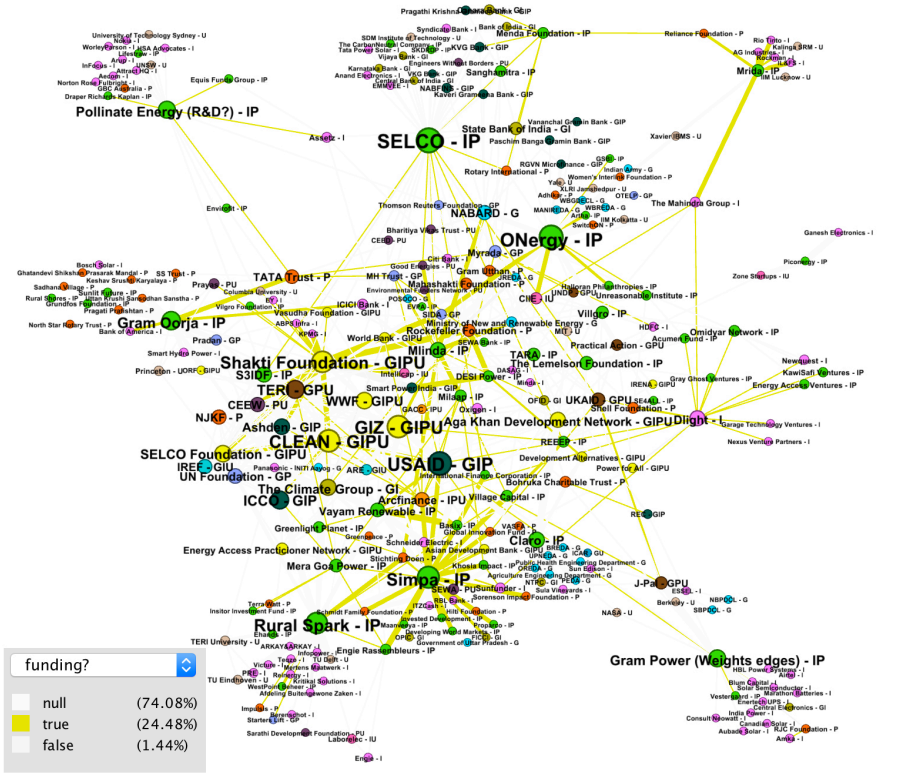


Figure D.3: All golden connections between node representing funding relations

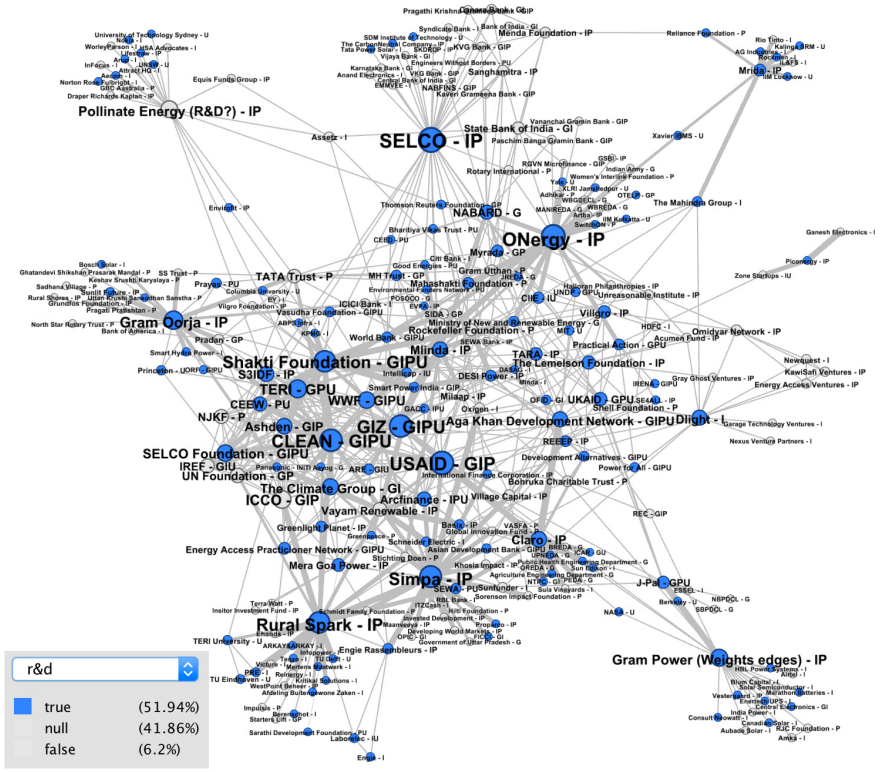


Figure D.4: In blue all organisations that perform R&D; Grey are not doing R&D

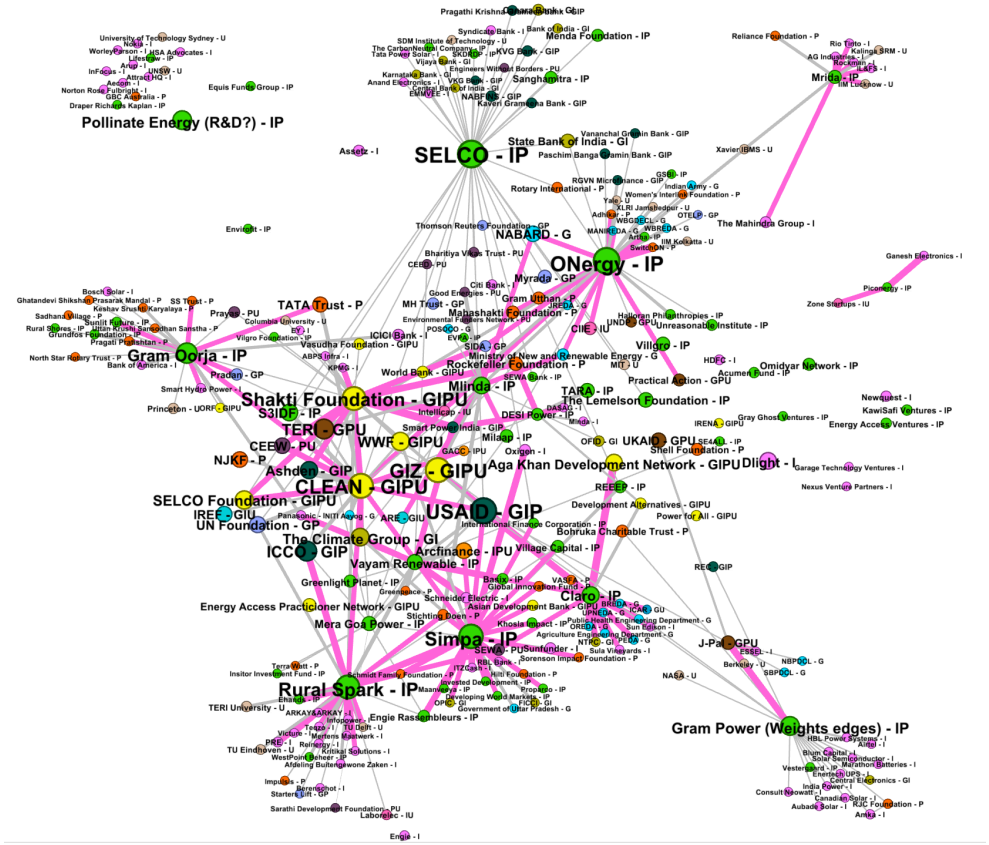


Figure D.5: The strength of relations with in pink at least monthly contact and in grey less often or not provided

Table D.6: Individual relations of interviewees that contribute to the Knowledge Space

Organisation	G	I	P	U	GI	GP	GU	IP	IU	PU	GIP	GPU	GIU	IPU	GIPU	tot.
Claro	1	-	-	-	-	-	-	1	-	1	1	-	-	-	2	5
DESI	-	2	1	-	-	-	-	1	-	-	1	-	-	-	2	7
Gram Oorja	-	3	3	1	-	1	-	3	-	1	-	-	-	-	4	16
Gram Power	-	1	-	1	-	-	-	1	-	-	1	1	-	-	1	6
Mera Goa	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	2
Mlinda	2	-	1	-	1	-	-	-	-	1	1	1	1	-	2	10
ONergy	1	-	1	4	-	2	-	4	1	-	-	1	-	-	2	16
Piconergy	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Rural Spark	-	5	-	3	-	-	-	1	-	-	-	-	-	-	2	11
SELCO	-	-	-	2	-	1	-	2	-	2	1	-	-	-	2	10
Simpa	1	4	-	-	1	-	-	1	-	-	-	-	-	1	4	12
Vayam	-	2	1	-	1	-	-	2	-	-	1	-	-	1	1	9
Mrida	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	3
CLEAN	1	-	1	-	1	-	-	10	-	-	-	-	-	1	4	18
J-Pal	2	1	-	1	-	-	-	1	-	-	-	-	-	-	-	5
Shakti	-	3	-	1	1	1	-	3	1	2	2	1	-	-	4	19
Total	8	21	8	16	5	5	-	30	3	8	8	5	1	3	30	150

Table D.7: Individual relations of interviewees that contribute to the Innovation Space

Organisation	G	I	P	U	GI	GP	GU	IP	IU	PU	GIP	GPU	GIU	IPU	GIPU	tot.
Claro	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DESI	-	2	1	-	-	-	-	1	-	-	1	-	-	-	1	6
Gram Oorja	-	2	-	1	-	-	-	-	-	1	-	-	-	-	3	7
Gram Power	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	2
Mera Goa	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Mlinda	-	-	-	-	1	-	-	-	-	-	-	1	-	-	1	3
ONergy	1	-	1	4	-	1	-	-	-	-	-	1	-	-	1	9
Piconergy	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Rural Spark	-	4	-	2	-	-	-	2	-	-	-	-	-	-	-	8
SELCO	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	3
Simpa	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	3
Vayam	-	2	1	-	1	-	-	2	-	-	-	-	-	1	-	7
Mrida	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CLEAN	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	2
J-Pal	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	2
Shakti	-	-	-	-	-	-	-	1	-	1	-	1	-	-	-	3
Total	1	13	3	8	2	1	-	11	1	2	1	5	-	1	8	57

D.3. D - Responsible Innovation - Results

The figure below shows the Consensus Space as it was in 2013, before CLEAN was formed.

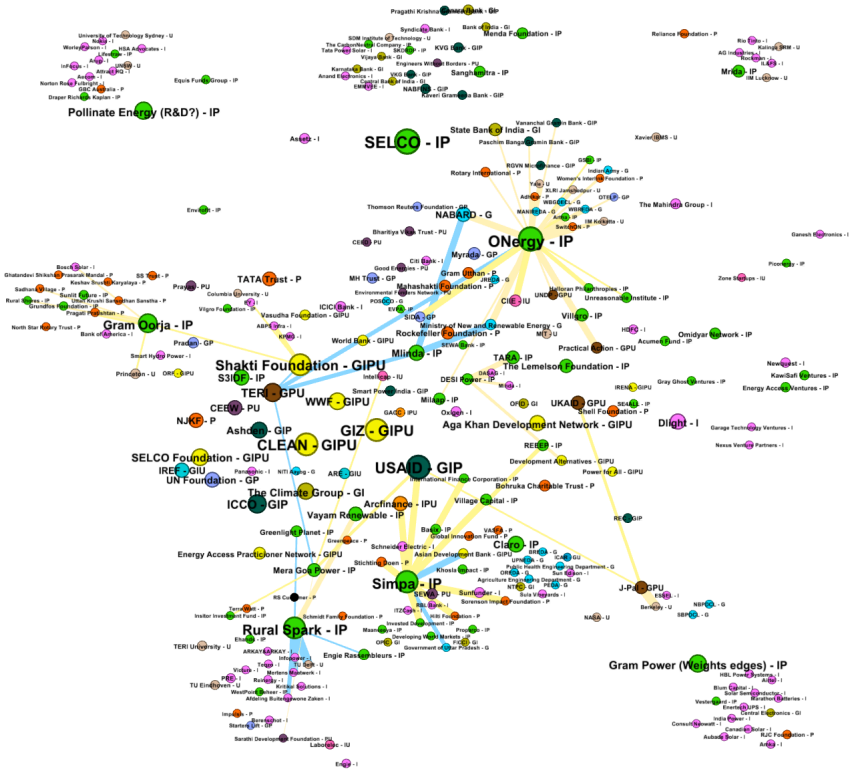


Figure D.6: In blue the relations contributing to the Consensus Space in 2013, in yellow relations that did not contribute

E

Raw Data Example

The figures in this Appendix chapter show a representation of how the data was collected in Google Sheets templates. Rural Spark is the particular organisation of which the templates are shown here.

Subject	Question	Note	Answer
A - Company Characteristics (ex-ante)	**In yellow are filled in by Yvo, with info from the website to safe some time for the interviewed company, please evaluate the answers for correctness**		
A1- Firm Size and Age	A1.1 When was the company founded		2011 (NL) 2013 (IN)
	A1.2 How many employees did the company have throughout the years?	*See Sheet 3*	*See Sheet 3*
	A1.3 What has been the yearly turnover	*See Sheet 3*	*See Sheet 3*
A2- Credit	A2.1 Has there been enough financial capital at hand and was this always this way?		No
	A2.2 What types of funding does the company collect? (seed, angel, VC, crowd, grants etc.)		Seed, grant, social funding, depth financing
	A2.3 Can the company already be profitable and self-sustaining?		No
A3- Education & human capital	A3.1 What level of education do the members of the board and the founders have?		Marcel van Heist (University) - Harmen van Heist (University) - Evan Mertens (University)
	A3.2 What fields of study have they pursued?		Marcel van Heist (Industrial Design) - Harmen van Heist (Organisation Studies) - Evan Mertens (Building services)
A4- Previous Experience	A4.1 If applicable, what was the former job position of members of the board and the founder(s)?		Marcel van Heist (student/ freelancer website development) - Harmen van Heist (student/ consultant) - Evan Mertens (student/ freelancer automation consultant)
	A4.2 How long have the members of the board and the founder(s) been professionally active in the region of operation?		Marcel van Heist (0.5 year) - Harmen van Heist (0.5) - Evan Mertens (3 years)
	A4.3 Was the company in question a so called 'spin-off' of another company?		No
A5- Innovation	A5.1 Is there currently innovation going on in services or product development?		Yes, the rural spark kit, with an innovative way of tracking customer payments
	A5.2 Was the motivation to start the company to make innovative products?		Was not the main goal, but more the solution to get the goals.
A6- Motivation starting company	A6.1 What was the main motivation for starting the company?		Impact realisation in energy infrastructure
	A6.2 Was the founder(s) unemployed before starting the company?		No
A7- Role of ethnicity	A7.1 What nationality and cultural groups do the founder(s) and members of the board have or belong to?		Dutch
B - Framework & Performance Compon	B1 Is the organisation a single- or multi-sphere institutional organisation?	*The possible institutions are University, Government, Industry and Public. Multi sphere means an organisation that covers multiple of these institutions*	multi-sphere
	B2 What institution(s) does the organisation belong to?		Industry/Public (until further notice of Esther)
	B3 Is the development on energy technology a main goal of the organisation, or does the initiative come from separate individuals within the organisation?		Yes, is the main goal
	B4 Is there any R&D happening internally in the organisation?		Yes, alone and in cooperation with others
	B5 How many people has the company provided with any form of electricity throughout the years?	*See sheet 3*	*See sheet 3*
	B6 How has the cumulative installed capacity (in kWh) changed over the years?	*See sheet 3*	*See sheet 3*
	B7 What has been the reduction in CO2 or kerosine (if available)?	*See sheet 3*	*See sheet 3*
C - Relations (seperate for each partner	C1 What kind of relation is there between the partner and your company?	*See sheet 2*	*See sheet 2*
	C2 When was the partnership and collaboration established?	*See sheet 2*	*See sheet 2*
	C3 How many contact moments are there monthly and has this changed?	*See sheet 2*	*See sheet 2*
	C4 Please describe the relation to the partner in terms of knowledge exchanges and techniques for getting to consensus on goals and expectations as are mentioned in the list of possible tools	*See sheet 2*	*See sheet 2*
	C5 Is the partner a single- or multi-sphere organisation?	*See sheet 2*	*See sheet 2*
	C6 What institutional sphere(s) does the partner belong to?	*See sheet 2*	*See sheet 2*
	C7 Is the partner doing any R&D activities?	*See sheet 2*	*See sheet 2*
	C8 Is the development on energy technology a main goal of the organisation, or does it come from individuals within?	*See sheet 2*	*See sheet 2*
D-Responsible Innovation Dimension	D1 What kind of activities were there performed to be able to anticipate future events?	*Examples are risk analysis/ scenario building/ forecasting*	Met TU eindhoven, intern Yvo, little government interaction. There is room for improvement, dependant on resources
	D2 What kind of activities were there performed to be able to reflect on the own organization and the collaborations with the partners?	*Examples are ethical guidelines/ codes of conduct*	Internal reviews and brainstorm every six months, no ethical guidelines. Room for improvement
	D3 Have all relevant stakeholders been included in the process and at what stage in the proces?	*Including customers and villages*	Yes has been tried, customers hidden design method, many pilots and interactions. Manufacturing supplier not, funding not really, relations within India. Government has not realt been included and embassy vould have been exploited more. Local universities some interns, no real projects
	D4 What kind of activities were there performed to be able to respond quickly to situations?	*Examples are shared goal determination, value based design, analysis of partners*	Not really devoted to contracts and lists of requirement, so that switching was possible until the last moment. Production was already started but had to be changed. Software and hardware didnt work, had to start initially. Targets have been adjusted a lot. Partnership building took way longer.
	D5 How does your company tackle issues regarding intellectual property in collaborative innovation?		With PRE, shared IP, they electronics, RS user interaction. Has been contracted with amount is given per product. With the university all IP goes to RS. NDA with some parties
	D6 Were there moments in the past where a structural change within your company was required or performed?		A little bit. Completely focus on products instead of distribution. Had to redesign the product at one point completely. Production has been stopped and whole organisation needs to go sales. Must say everything works pretty well.
E- Pilot projects	E1 Where are the pilot projects located of your company		Bihar
	E2 Would there be a possibility for Yvo to visit projects and talk to local customers about the experiences and perceptions on the products?	*In this case I will share my envisioned questions up forehand with your company*	Yes very welcome to pilot project in Banky Bazar, Bihar

Figure E.1: Interview Rural Spark - 1

Interview on Partner Collaborations & Relations - Rural Spark - Sheet2 - Collaboration & Relations

Partner	Type of organization	Located in	Year of start coll	Contact frequency	Type of contact	A relevant contact	Type of Relation	Devoted to electrifica	R&D in the organisation	Description of nature of relation, with a
Dia Administratie	Industry (I)	Netherlands	2011	Monthly	Both		Supplier	No	No	Administration
Afdeling Buitengewone Zaken	Industry (I)	Netherlands	2011	Quarterly	Both		Other or multiple (plea	No	Yes	Social design of product development, der
Vayam Renewable (formerly IGS (NC	Industry (I)	India	2011	Quarterly	Both		Other or multiple (plea	Yes	No	Distribution party, paid to get products to c
Basix (is Vayam)	Intermediary (IP)	India	2011	Quarterly	Both		Other or multiple (plea	No	Yes	Same as Vayam, but mother organisation
Cofely	Industry (I)	Netherlands	2011	Quarterly	Formal (official meeting		Joint R&D Project	No	Yes	Part of engie, potential to joint R&D but no
Mertens Maatwerk	Industry (I)	Netherlands	2011	Weekly	Both		Supplier	No	Yes	Electronics development
BoP Innovation Centre	Industry (I)	Netherlands	2011	Yearly	Informal (oral or email)		Strategic Alliance	No	Yes	advisor role for partnerships, takes the role
Triodos Foundation	Public (P) (or representing	Netherlands	2012	Never	Formal (official meeting		Funding	No	No	funding nothing more
SELCO	Intermediary (IP)	India	2012	Quarterly	Informal (oral or email)		Customer	Yes	Yes	Potential customer, strategic alliance. Sho
BiD Network	Unknown	Netherlands	2013	Never	Informal (oral or email)		Other or multiple (plea	No	unknown	accelerator for startups, won a price, acts
Embassy of the Kingdom of the Neth	Government (G)	India	2013	Quarterly	Informal (oral or email)		Strategic Alliance	No	Yes	Connecting with interesting parties, act as
TU Delft	Academic (U)	Netherlands	2013	Weekly	Both		Human Capital Excha	No	Yes	Allemaal human capital exchange
Simpa	Intermediary (IP)	India	2013	Weekly	Both		Customer	Yes	Yes	Check IP, distribution partner, last mile cor
Engie Rassembleurs	Intermediary (IP)	Netherlands	2013	Yearly	Formal (official meeting		Funding	Yes	Yes	Connected engie, they want more then fun
Greenlight Planet	Industry (I)	India	2013	Yearly	Both		Supplier	Yes	Yes	Supplier of lamps
Kritikal Solutions	Industry (I)		2014	Monthly	Both		Supplier	No	Yes	Electronics development
PRE	Industry (I)	Netherlands	2014	Weekly	Both		Supplier	No	Yes	Also part of R&D project with eindhoven, b
Impulsis	Public (P) (or representing	Netherlands	2014	Yearly	Formal (official meeting		Funding	No	No	only funding, but don't exist anymore (che
Starters Lift	Intermediary (GP)	Netherlands	2014	Yearly	Formal (official meeting		Funding	No	No	only funding, not much more. So in the beg
Village Capital	Industry (I)	Netherlands	2014	Yearly	Formal (official meeting	vilcap.com	Funding	No	No	funding nothing more, 1 yearly report, cons
Berenschot	Industry (I)	Netherlands	2014	Yearly	Formal (official meeting		Other or multiple (plea	No	Yes	consultant
Laborelec	Intermediary (IU)	Belgium	2014	Yearly	Formal (official meeting		Joint R&D Project	No	Yes	check for IU, could be both. Strong knowle
EBTC	Government (G)		2014	Yearly	Informal (oral or email)		Strategic Alliance	No	Yes	Check if G is oke, same as BoP
Infopower	Industry (I)	India	2015	Daily	Both		Supplier	No	No	Just telling them what to do, very little kno
Stichting Doen	Public (P) (or representing	Netherlands	2015	Monthly	Formal (official meeting		Funding	No	No	Funding nothing more, every month report
Clean	Intermediary (GIP)	India	2015	Monthly	Both		Strategic Alliance	Yes	Yes	Big network of all developers of energy tec
Nestingbits	Industry (I)	Netherlands	2015	Never	Informal (oral or email)		Supplier	No	Yes	Software developed, internal firmware.
TERI University	Academic (U)	India	2015	Quarterly	Both		Joint R&D Project	Yes	Yes	Also human capital exchange! Together in
TU Eindhoven	Academic (U)	Netherlands	2015	Quarterly	Both		Joint R&D Project	No	Yes	Together with teri university, R&D project,
West Point beheer .nl	Intermediary (IP)	Netherlands	2015	Quarterly	Both		Funding	No	No	individual funder
SELCO foundation	Public (P) (or representing	India	2015	Quarterly	Informal (oral or email)		Customer	Yes	Yes	Potential link to customers, intensive collal
Teqzo	Industry (I)	India	2015	Weekly	Both		Supplier	No	Yes	Casing for all products designed
Ehands	Industry (I)	Netherlands	2016	Daily	Informal (oral or email)		Customer of Products	Yes	No	Mogelijke distributie, mondelijke target, ge
Victure	Industry (I)		2016	Monthly	Both		Supplier	No	Yes	Do some product development but project
SEWA	Public (P) (or representing		2016	Monthly	Informal (oral or email)		Customer	No	Yes	Have done cultural analysis, goal determin
Reinergy	Industry (I)		2016	Monthly	Informal (oral or email)		Customer	Yes	No	Showed interest in product and have discu
ICCO	Intermediary (GP)		2016	Weekly	Both		Customer	No	Yes	Partner for joint project funding application
ARKAY&ARKAY	Industry (I)		2016	Weekly	Both		Supplier	No	Yes	Accountant, do research on blockchain str
Shakti	Intermediary (GIPU)	India	2016	Yearly	Formal (official meeting		Knowledge Exchange	No	Yes	
CEEW			2017	Monthly	Informal (oral or email)					
J-Pal			2017	Monthly	Informal (oral or email)					
Alliander			2017	Monthly	Informal (oral or email)					
Moserbear	Industry (I)		2017	Yearly	Formal (official meeting		Supplier	No	Yes	Supplyer of solar panels, one of the bigge
Rijksdienst voor Ondernemend Nede	Government (G)	Netherlands	??	?						??

Figure E.2: Interview Rural Spark - 2

Interview on Partner Collaborations & Relations - Rural Spark - Sheet3 - Electrification data

Year	Number of electrified customers	Cumulative installed capacity (kW)	Turnover (rupee)	Number of Employees	Cumulative Co2 reduction or kerosine prevention
1995	0	0	0	0	0
1996	0	0	0	0	0
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	0	0	0	0	0
2000	0	0	0	0	0
2001	0	0	0	0	0
2002	0	0	0	0	0
2003	0	0	0	0	0
2004	0	0	0	0	0
2005	0	0	0	0	0
2006	0	0	0	0	0
2007	0	0	0	0	0
2008	0	0	0	0	0
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	20	0.13	7000	3	?
2012	50	0.3333333333	17500	3	?
2013	500	3.333333333	175000	4	?
2014	1500	10	525000	5	?
2015	1000	6.666666667	350000	6	?
2016	750	5	262500	11	?
2017	*60000*	*200*	*75000000*	*16*	*?*
2018	*1080000*	*3600*	*1350000000*	*26*	*?*
2019	*2400000*	*8000*	*3000000000*	*50*	*?*
2020	-	-	-	-	

Figure E.3: Interview Rural Spark - 3

F

Policy Analysis - from Internship Report Yvo Hunink 2016

This section was added to give a better representation of the policy environment of rural energy technology in India. A great number of citations are not included, to protect the intellectual property of Rural Spark, who ordered the creation of the report where this section can be found. Those citations are all represented with ?, expect for the ones that are also mentioned in this report

A wide network of policy and regulations around energy technologies in India have been established during latest decades. The Indian power sector has been intensively reformed. It followed a trend in world were the goal is to open the energy sector to private investments. This restructuring of the sector and its impacts are reviewed at the beginning of this section. Further on the current regime of regulations is described. In advance, there will be a discussion about the impacts and effects that surround introduction of energy technology policies, and therefore future grids.

F.1. Indian Power Sector Reforms

From independence, India followed the regulations laid out by the Electricity Act of 1948. The act structured the sector in divisions of generation, transmission and distribution. Centrally organised, these divisions where fully vertically integrated and created a monopoly for public institutions. State Electricity Boards (SEBs)) were founded at state level. From 1950 the central government received the same rights as the state to operate in this field. It appeared, in the early 1990s, that the boards were failing to cover their costs, because of inadequate generation capacity, high technical losses and poor financial conditions of SEBs. A large part of this was due to the subsidies that were given on electricity, originally to boost development of the population with low tariffs. Costs were usually balanced with higher tariffs for industry, but these were increasingly seeking their own energy generation solutions. The shortfall was being drawn from the governments funds. **? ?** It was obvious that reforms were needed.

The following waves of policy and regulations can be divided in two main phases. The first phase is the introduction of reforms in 1991. These reforms were somewhat successful in creating independent Electricity Regulatory Commissions (ERCs) at the central and state level, making unbundling of the vertically integrated divisions possible, increasing commercial autonomy for companies, capacity building activities and more transparant governing regarding subsidies and regulations. **?** However, the reforms didn't manage to improve the financial situations of the SEBs, while private introduction in the market was still very limited. The government had to put out a second reformed structure in order to fully boost the reviving of the power sector. Therefore the Electricity Act of 2003 was introduced as the second phase of reforms, under aid of the World Bank. The act replaced all previous legislation and made the formation of State ERCs obligatory, aimed at higher electricity tariffs to cover costs, provide open acces to third parties and private businesses. Not only did it seek to reform structurally, but it also tried to make the market competitive and efficient. In the following subsection we will further elaborate on the Energy Act and other energy and grid related policies that are active at the moment

and discuss the impacts and effects.

F.2. Current Energy Policies

India's rising energy demands need to be supplied. The country has laid out ambitious plans to increase renewable and nuclear energy technologies and has put in place several programmes to accelerate these developments. General energy policies are of importance to microgrid developers, since introduction of more generation will automatically lead to the necessity of grids to transfer the energy. The larger part of policy programme activities in renewable energy technologies is acted through the Ministry of New and Renewable Energy (MNRE) with at the head of the ministry Piyush Goyal. This subsection describes the current energy policy programmes and regulations that are of influence for parties willing to develop microgrids. Other literature has done a similar study for solar power in India. **?** In Figure F.1 an overview of the structure of energy policies is given. State policies are widely derived from national policies and are therefore not discussed, however, when at the start of activities, it is wise to gain contacts within this state level organisation that make the policies.

F.2.1. Electricity Act of 2003

The Electricity Act of 2003 aimed to transform the power sector as a whole by replacing three older acts from 1910, 1948 and 1998. The act has made issues like rural electrification, generation, transmission and distribution a key point on the agenda. Also consumer protection, tariff principles, energy theft, trading development and grid connectivity are subjects that are treated in the act. Next to that the act sees to restructure the SEBs towards the Central Energy Regulatory Commission (CERC) and the State Energy Regulatory Commissions (SERCs), acting as an independent regulator in the energy market. Parallel to these regulatory commissions, the act sees that a Forum of Regulators (FoR) is installed, consisting of the chairman of the CERC and all the SERCs. The FoR meets at least twice a year and discusses all relevant data coming from the regulatory commission and sees to harmonise the policy decisions. **?**

The act has also established the Central Energy Authority (CEA).**?** The CEA advices the government in policy and technical matters and forms short-term plans for development and implementation of electricity systems. It is also responsible for handling of all data regarding the power sector. Most importantly, in the case of Rural Spark, does the CEA set the standard for electricity lines and grid connections.

During the past decade several amendments were done to the act, but the most recently proposed one will impact the sector substantially. The proposed amendment consists of the provision for private parties to supply energy to customers without having to own the distribution lines. As the Piyush Goyal stated the amendment seeks to end the monopoly of power distribution companies by segregating the carriage (distribution sector/network) from the content (electricity supply business) in the power sector by introducing multiple supply licensees so as to bring in further competition and efficiency in the distribution sector by giving choice to the consumers. **?**

F.2.2. National Electricity Policy 2005

The National Electricity Policy aims at accelerated development of power sector, providing supply of electricity to all areas and protecting interests of consumers and other stakeholders by the year of 2012. **?** It is one of the key instruments in providing policy guidance for Electricity Regulatory Commissions and the CEA. It saw to provide a per capita availability of 1000 kWh and other objectives. These targets were largely not reached and therefore the act is still very actual. Next to some targets, the act has also obliged the CEA to construct a National Energy Plan every 5 years.

F.2.3. Tariff Policy 2006

The Tariff Policy was introduced in 2006. Its objectives are: Ensuring availability of electricity to consumers at reasonable and competitive rates; Ensuring financial viability of the sector and attract investment; Promote transparency, consistency and predictability in regulatory approaches across jurisdictions and minimise perceptions of regulatory risk; Promote competition, efficiency in operations and improvement in quality. The policy introduced a minimum percentage in purchase of energy from non-conventional sources. Furthermore it installed the Availability Based Tariff (ABT). This is a performance-based tariff for the supply of electricity. The ATB structure has led to a new system of

scheduling and dispatching, making a day head schedules necessary for generators and beneficiaries of energy. Penalties can be given if this is not followed. **?**

In December 2015, the first amendment to the policy was approved by the Union Cabinet. A total of 19 main objectives are presented in the subjects of electricity, environment, energy efficiency and easiness of doing business, of which the following are of most important to the case of Rural Spark **?**:

- 24X7 supply will be ensured to all consumers and State Governments and regulators will devise a power supply trajectory to achieve this
- Power to be provided to remote unconnected villages through micro grids with provision for purchase of power into the grid as and when the grid reaches there.
- Faster installation of Smart meters to enable 'Time of Day' metering, reduce theft and allow net-metering.
- Ancillary services to support grid operation for expansion of renewable energy.

These objectives will help some of the problems that are still present in the regime. We will discuss this further in Section F.3.

F.2.4. Integrated Energy Policy

The integrated Energy Policy was introduced in 2006 and was the largest document in its kind, counting more than 180 pages of integrating solutions to further enhance efficiency in energy use and generation. It is specifically aiming for long term solutions for sustaining growth in the energy sector. One of the solutions that is presented in the document is the Feed In Tariff (FIT). **?** The FIT is a form of policy programme that should accelerate investments in RETs. A FIT generally promises three key things, namely guaranteed grid acces, long-term contracts and cost-based purchase prices of energy. **?** Current tariffs for solar PV, solar thermalis fixed at Rs. 17.90 (USD 0.397)/kWh, Rs. 15.40 (USD 0.342/kWh). The tariffs are determined and reviewed periodically by the CERC. **?**

F.2.5. National Rural Electrification Policies 2006

The national Rural Electrification Policies were introduced in 2006 aiming at the following objectives **?**:

- Provision of access to electricity to all households by year 2009
- Quality and reliable power supply at reasonable rates
- Minimum lifeline consumption of 1 kWh per household per day as a merit good by year 2012

Since these target are not yet made, they are still relevant. Within the Rural Electrification Policies the State Governments were obliged to set up Rural Electrification Plans, in order to speed up the developments. Another important feature for the case in Rural Spark is that is set out to enable franchise agreements for local management of rural distribution of electricity.

F.2.6. National Action Plan on Climate Change (NAPCC) 2008

With climate change becoming increasingly important, since impacts could be felt in India at every geographic location in the country, the government increased the policy possibilities in dealing with this threat. The NAPCC was introduced in 2008, giving way for economic objectives in the first place, while keeping environmental obligations strongly in mind. **?** The plan says: 'India's CO2 emmissions will at no point exceed that of developed countries even as we pursue our development objectives.' **?** The plan is divided in 8 national missions of which the Jawaharlal Nehru National Solar Mission (JNNSM) and the National Mission for Enhanced Energy Efficiency (NMEEE) are to ones most applicable to Rural Spark's case. JNNSM had as objective to make solar power cost competitive with fossil fuels, which is lately starting to become true. It also plans to install 22GW of solar power by 2022, with grid connected and off grid power plants, all next to other solar power targets of the country. The NMEE saw to improve demand management by saving at least 10 GW of energy at the end of the 11th five year plan and possibly more in the next five year plans. Tripathi et al. (2016)

F.2.7. Five-Year Plans

After independence, India started to rely on planning. It formed the Planning Commission who has as one of its objectives to make five-yearly plans. The plans are centralised and integrated economic programmes focussing on growth. India's first five year plan was introduced in 1951 containing some policies in energy demand projection. In further plans, energy has always been a main component. Currently the 12th five-year plan is at work until 2017. One important energy related target in it to have power generation capacity of renewable sources up to 41.4 GW in 2017. Current capacities are already passing this line, so the target is going to be reached. After the 12th plan the Central Planning Commission will be dismembered and replaced by the National Institution for Transforming India Aayog, which takes the form of a think thank and will be responsible for the five-year plans from that moment on.

Figure F.1: Energy policies announced by the government of India **?**

F.3. Impact and Effects

Most of the energy policies in India have been active for several years and therefore their impacts and effects can be reviewed, which is done in this section. Introduction of the reforms such as SERCs, tariff orders, unbundling of the sector, financial healing of the sector and electricity efficiency reforms will be looked in to and evaluated on the desired outcome. We will divide the section in the effects and impacts of structural reforms, the strive for privatisation and the most recent announced developments that cover shortcomings derived from these effects.

F.3.1. Structural Reforms

In Table **??** in the Appendix, the dates in which SERCs, tariff order and electricity reforms were installed are shown for all States. What is clear from the table is that the dates vary enormously, up to almost 10 years. This means, for example, that the SERC of Bihar, which was installed in 2005, is missing many years of experience of regulating the energy sector compared to the state of Orissa, which was the first in 1996. However, every state has now introduced reforms, therefore making it that the structural policies proved effective. In Table **??** the same can be found for the unbundling of the power sector for each state. In the table G, T and D stand for respectively generation, transmission and distribution. GTD means a monopoly was maintained where every division was vertically integrated. G-TD means partially unbundled where generation is completely independent and transmission is still combined with distribution. G-T-D is a fully unbundled structure, where all divisions are completely separate and GD-T is the partially unbundled structure with transmission being separate. It must be noted that the table is somewhat outdated and the states of Bihar and Jharkand have adopted a G-T-D structure as well. **?** While there is a large difference between states in timing and the structure of the unbundling, a study by Malik et al. didn't find any particular reason or motivation for this. **?** Table **??** shows that unbundling of the sector can happen gradually in stages. What also can be noted is that the late adopters take the step towards the GD-T system, rather than a full unbundling. The study of Mahadeo tells us why.

The Mahadeo study uses a two-stage bootstrap-DEA methodology that, in its own words, fills up many of the gaps that former research on this topic left for collecting precise results. Instead of focussing on his method, however, let us focus on his results. The results had to show the efficiencies of the distribution companies in their activities and wether certain external variables are of influence to it. Some interesting findings from the study can be mentioned here. First it was found that being a public owned utility in India in general gives efficiency advantages over private utilities. The reason for this is still unclear and should be further researched in a later stadium. Second, however, it was found that in densely populated areas, private companies outperform private companies. It seems that certain technical advantages exist for private companies when dealing with a larger number of customers in a smaller area. A third interesting finding is concerned with the unbundling of the sector. Mahadeo finds that there is strong empirical evidence of the GD-T structure having a significant potential positive impact on the technical efficiency, irrespective of the size of a distribution region. It seems that generation and distribution, which are completely different activities, have some sort synergetic advantages in technical efficiency for the distribution sector. When size is taken into account, however, something interesting comes up. For smaller states and regions, a GD-T structure or fully unbundled

G-T-D is living up to the potential efficiency improvements. Medium sized states, however, don't seem to live up to the efficiency potential. This is mainly because of their slow operations and difficulties in adjusting their operations to the new environment. This implicates that for medium sized states it could be beneficial to unbundle their operations horizontally as well, dividing the region in smaller parts. If this policy advice is ever adopted, it creates a space for Rural Spark to take over operations over a region. The last important finding of Mahadeo is that the state-level electricity reforms have had a significantly negative effect on the technical efficiencies in distribution regions. Since these reforms are often based on the national reform policies, this can causally be directed to the national policies. There appears to be a lot of uncertainty around policies, which can somewhat be seen in previous subsection, where many different policies try to tackle the same problems in different ways and with different people responsible. A study by Pargal and Banerjee confirms this view and concludes that the distribution sector in India is still not profitable and efficient after more than 20 years of reforms. **?**

F.3.2. Failed Privatisation

Since the reforms made privatisation of the sector a priority, the reasons for the lack of efficiency in the sector might have something to do with this. The reasons for privatisation in India can be summarised in the following aspects **?**:

- Managerial and financial systems needed to be improved and a more consumer focussed culture adopted.
- Financial means for investments and maintenance needed to be brought in.
- Political influences needed to reduce so that, for example, non-payers could be disconnected without the fear of public dissatisfaction.

What becomes clear from these reasons, is that the introduction of the private sector is not so much about the advantages it brings, but more about the shortcomings of the public sector that it is supposed to solve. The study by Lahiri et al. says that privatisation in energy distribution has been problematic in a number of cases. Even though revenue collection has generally gone up, and technical problems of the systems have gone down, new problems have emerged. Lahiri seriously questions if privatisation is pro-poor, since powerful corporate interest is being created and a reliable energy supply to people who can not pay for it is not profitable. Rural Spark, however, is not comparable to these private companies and this must be made very clear to the stakeholders. Rural Spark aims to make unprofitable areas profitable through innovation.

Electrification technologies are categorised into five scales. Alstone et al. (2015) Charging things such as mobile phones is considered the smallest scale. Pico-power systems are considered secondly, containing services such as lightning. Solar Home Systems are third, including all former and household items such as televisions and fans. Fourth is the microgrid and fifth and last is the central or regional grid. Table **??** in the Appendix shows more information about the five scales and an economic, geographic and political barrier for each scale. Rural Spark is currently active in the first two scales and actively exploring possibilities in the third and fourth. The inflow of private capital differs between scales, but is lacking behind significantly in the microgrid segment. **?** The largest public off grid microgrid installer has been the State of Chhattisgarh, delivering up to 1400 off grid habitations in the last decade, though private parties do not seem to keep their heads above the water in the microgrid scale of electrification technologies. Husk Power installed some biomass based microgrids, but has reduced their activities and is considering moving to Africa. SunEdison only targets area's where they are able to get subsidy, which often means these areas are very remote and not reachable by the central grid. Other microgrid investors are Kuvam Microgrid, Gram Power and Azure Power, but these are not growing rapidly either. **?** Literature finds that India attracted many foreign and private investments, but found mortality rates in the development stage to be large. Some major drawbacks can even be seen from projects of Dabhol and Tamil Nadu. **?**

A study by Kessides Kessides (2012) provides two insights that might explain the failed privatisation in the microgrid segment. First Kessides says, electricity market reforms can only be successful if certain requirements are met, with respect to commitment-to-reform, legal and financial infrastructure and other institutional issues that are often not present in developing countries. In absence of these, a new hybrid model was introduced, also in India, where Independent Power Producers (IPPs) perform an important role next to the public energy companies. This model's success depends, however, on

a stable and coherent policy framework around it, with specific attention to planning, procurement and contracting. Variations within State policies, regulations, constant reforms and absent frameworks for agreements on the microgrid scale have not provided that. Secondly, the study by Kessides says there is a certain order of reforms that has to be followed. First raise prices to cost-covering levels, second create regulatory institutions, third restructure the sector and only then privatise. It is costly to maintain a different order and this is exactly what India has done. Before prices where raised to cover the costs, privatisation was already introduced, making it very hard to persuade customers from loss making public DISCOMS to go to private parties. This and a number of other barriers are still present in the current environment.

It is not only difficult for microgrid operators to attract customers in areas where public DISCOMS are active, but it is also difficult to keep them connected in areas where the public DISCOMS were (formerly) not active. A working paper by Stanford has reviewed the implications for microgrid development in India and elaborates further on issues that Kessides found too. Their conclusions are drawn from interviews with a total of 71 persons that are in high ranks in the energy sector in India, including policy makers, investors, project developers and industry analysts.**?** The paper makes the observation of development problems for microgrids and tries to find the main barrier for implementation. The first discovery that is done, is that microgrids are are cost competitive against traditional fuels, such as kerosine. However, microgrids can not compete against the tariffs of the central grid, which is low because of the long tradition of subsidising on energy, as earlier mentioned. In Figure F.2 the levelised cost of energy (LCOE) is presented for different energy services.

Figure F.2: LCOE of alternative energy services **?**

The second finding is directly connected to this. As will be further explained in Section **??**, barriers for technological development can be divided in financial, economic, socio-cultural, technical and regulatory. The first four of these types of barriers can be mitigated by project developers and investors, however regulatory barriers are out of their control. It is up to policy makers to mitigate those barriers. From the interviews appeared that the main barrier, or gateway barrier in the literature, consists of the thread of central grid extension to a microgrid area, which can be seen as regulatory barrier. Because of the much lower prices for electricity, customers will then switch to the central grid. This would evaporate investments that were done in the microgrid at an instant, making it very unattractive to develop such a project.

So the question rises: Why can the central grid be so easily extended, without considering the microgrid investments? The answer lies in the Energy Act of 2003. The need for a license to build, own and operate an electricity generation and/or distribution entity was removed in the act. The paradox is that this was originally done to attract more private capital. In reality, however, it has created an environment where privately owned microgrids are not protected against sudden intrusion of the central grid. A reason for the sudden intrusion might be explained due to the fact that electricity is still used as political tool, even though on paper this should not be the case. This means that in practice, because of whatever reason, the central grid can decide to electrify a village overnight if the responsible person decides it should be. If there was to be a disagreement between the microgrid operator and the government, the activities of the DISCOM could be misused through political influence of the government in these institutions. This is acknowledged by the interviewees, consisting of mostly policy makers and are therefore being recognised at the moment. Appropriate measures are being constructed to improve on these shortcomings, which will be further elaborated on in next subsection.

F.3.3. Latest Developments in Microgrid Policies and Regulations

The energy technology environment in India is constantly changing. The formerly described energy policies in Section F.2 have a more general scope for development of energy technologies. Recently, however, a more specified scope towards smart and microgrids is being formed. Many of the formerly described barriers are being discussed and possible solutions are provided. This subsections aims to present the latest progress in regulations and policy that are attacking the specific problems that occur in microgrid development. Some governmental programmes, schemes and policy advices are reviewed here.

The Indian Government has not been sitting still. The Ministry of New and Renewable Energy (MNRE) in particular is very active in the electrification targets for the country. Its head of chair, Piyush

Gidal is also very active on Facebook, sometimes posting up to 15 times a day about electrified villages and installed solar panels and so on. While much of it is, of course, propaganda, every now and then some important signs of real development are shining through. On the 4th of June he posted a link to a news website. **?** The article explains the rollout of SCADA control systems for the real time monitoring of electrical networks. On top of that a cloud platform is being developed, as was explained in Section **??**, to be able to perform complicated calculations. It even has the goal to make this information readily available from the GARV board. The GARV board is the online available monitoring board where the MNRE keeps track of the number of villages that are electrified and its responsible electrical engineers in the form of GVAs. **?**

Initiatives as the GARV board and bringing SCADA control systems to grids are all backed by a number of schemes and programmes, often also initiated within states. A few will be briefly mentioned that have come by in literature, but this is merely a selection of the many committees and boards that are to be found in a bureaucratic country such as India. The National Smart Grids Mission initiated by the Minstry of Power (MoP) in 2014 has a large share in accelerating developments in smart grids. A number of interesting papers, on for example dynamic tariffs, are freely available from the website. **?** Another programme is the Ujwal DISCOM Assurance Yojana (UDAY). It was started in November 2015 to help better the financial situations of DISCOMS in the country. UDAY is effectively a way for the state to take over the large debts of the DISCOMS. States that are following the suggestions of UDAY and performing well are candidates for further funding through the Deendayal Upadhyaya Gram Jyoti Yojana (DDUGJY) scheme, Integrated Power Development Scheme (IPDS), Power Sector Development Fund (PSDF) and other such schemes of the MoP and MNRE. Furthermore there are the Village Energy Security Programme (VESP) and Remote Village Electrification Programme (RVEP) that see to the installation of grids in villages and remote places. As can be seen, there is no shortage of schemes and programmes. Very little of them, however, address the gateway barrier being the lack of a regulatory framework for microgrid operators.

Here, the position of the Forum of Regulators (FoR) proves to be important, as introduced in Section F.2.1. In 2012 the FoR has released a policy advice in the form of the report *Draft Guidelines for Off Grid Distributed Generation and Supply Framework* **?** The lack of a regulatory framework around microgrid operators is tackled in the proposale. Its solution is to make the microgrid operator a licensee of the distribution company, effectively becoming a *Rural System Operator* (RSO). The most important aspect of the proposal is the enactment of a Power Purchasing Agreement (PPA) that obligates the distribution company to buy pre-specified amounts of electricity from the RSO at the feed-in-tariff for a period that would make sense in respect to the investment costs done for the infrastructure. This would mean security of investment for the RSO and a better cooperation between the entities, instead of competing for the same customers. This policy advise, however, has not been taken up into the current policies, even though the proposal's creators are the heads of CERC and the SERCs. This could perhaps be addressed to the issue that this does not solve the financial problems of the DISCOMs, since they are still obliged to buy the electricity at higher prices than they sell. However, a turning point may also be expected, since the cost of solar power has dropped beneath the fossil fuel price in India. This would make the incentive to arrange the PPA much larger, since it reduces the costs for DISCOMs. Advice to Rural Spark would be to seek DISCOMs willing to sign such agreements, adopting policy, before it has been installed.

Very recently the MNRE has released a draft for a national policy on mini/micro grids to stakeholders (NPREMM). MNRE (2016) Until the 20th of June, comments can be submitted to the board responsible to an email-address provided in the document. In its introduction, the policy speaks of Energy Service Companies (ESCOs) and Rural Energy Service Providers (RESPs). The latter being a new entity the government wants to create. RESP are effectively the RSO's that where proposed by the FoR, but with some interesting additions. The RESPs will earn certain privileges for implementation under the Ministry's programmes, of which a PPA structure, as earlier proposed by the FoR. RESPs will also be allowed to have multiple revenue streams through providing auxiliary services, such as internet, medical and educational services, potable water, skills and training, shops selling mobile phones, cable connections etc. within the community. It is a key element for Rural Spark to aim in becoming a RESP, in order to develop their technologies under the wings of the Government. In the Viable Implementations of Section **??** the concept of becoming a RESP is further elaborated.

Another important aspect of the new policy regime is the interconnection with the central, grid. Current regulations oblige the microgrid operator to stop supply of energy from a generator whenever

the DISCOM grid fails, as earlier experiences with unstable microgrids have proved harmful to the central grid. The new policy would provide openings for agreements if the microgrid operator, or in the future the RESP, can prove it is able to perform islanding control operations of the microgrid. With Rural Spark being a stakeholder for development around this policy, a suggested comment was made for submitting to the policymakers in the Appendix in Section **??**

Lastly, the policy will ensure the inclusion of inhabitants in energy processes with the empowerement of the Village Energy Committee (VEC). Its role will be to promote energy technologies and products and to make the village aware of the latest developments around the village grid. It will also join a cooperation between the State Nodal Agency (SNA) and the ESCO in pursuing the best possible service to be delivered to the communities. The SNA will act as a regulator much like the SERCs are for the entire power sector.

G

Can Blockchain help reduce energy poverty in rural India?

This piece of text was originally published in a three-piece article on https://medium.com/@yvohunink, for the original hyperlinks in the text, please visit that webpage.

The energy sector in India is at a crucial turning point in time. No less then 240 million people that are yet deprived of access to energy, but are on the verge of being electrified because of dropping prices in solar energy generation, storage and infrastructure innovation. In this small series of articles, I will explore a small set of problems that are apparent in the sector and will hold this to the light of Blockchain technology, that is becoming more and more seen as a resourceful solution for use in the energy world. This first article will sketch the problem definition from an Indian perspective. The second article will pose as a general introduction to Blockchain technology and the third article tries to connect the dots where problem and solution could meet.

So let's sketch the problem, where it must be disclaimed that this is but a fraction of the issues faced in the rural energy technology sector today. The objective of rural electrification is pursued by many different organisations, in the industrial, governmental, academic and public spheres. Both bottom-up as top-down approaches are being tried, on which perspective Rob de Jeu has written an interesting piece. A coherent cooperation between parties, however, seems almost absent. While latest policies in, for example, Bihar, have tried to close the gap between microgrid operators and distribution companies (DISCOMs/utilities), there is still little willingness between the parties to work together on a large-scale level.

Microgrid operators are largely private entities, facilitating energy services in villages and remote areas that are often not reached by the central grid. DISCOMs are the operators of that central grid and are still profoundly loss-making public organisations, even though that is not required. Microgrid operators and DISCOMs need to start collaborating, there were the central grid gets extended to areas where microgrids are already installed.

The Government of India has reformed the energy sector immensely in the past decades, because the model was unsustainable and loss making. However, attempts to attract more private companies in the distribution sector in order to restore its performance has not been as effective as anticipated. A study by Kessides sheds a light on the possible reasons for this. According to Kessides, there is a certain order of reforms that has to be followed. First raise prices to cost-covering levels, second create regulatory institutions, third restructure the sector and only then privatise. It is costly to maintain a different order and this is exactly what India has done. The highly subsidised DISCOMS were, at the time of privatisation, still offering electricity at prices below the cost of producing it, coming from the time where the Government wanted to speed up electrification by making it possible through low prices for rural customers. Before prices were raised to cover the costs of electricity, privatisation was already introduced, making it very hard to persuade customers from loss making public DISCOMS to go to private DISCOM parties.

Attracting private investment for microgrids also not had the expected impact. A working paper by a PhD student from Stanford tried to find the 'gateway' barrier to microgrid implementation. The biggest barrier was not a lack of cost competitiveness, as one would expect, but a competition between the DISCOM and the microgrid operator. When the central grid of the DISCOM gets expanded to the rural area, it gives the villagers a cheaper form of energy access, with which the microgrid cannot compete, because the DISCOM is so heavily subsidised.

This barrier has been acknowledged by the governmental entities. Bihar, one of the States most deprived of energy access is creating a lot of policy on the matter. In the latest draft policy on microgrids it has been tried to resolve the 'gateway barrier'. At the moment that the central grid is extended to the area, the DISCOM has to take over the assets of microgrid operator (the network) according to the current booking value. Furthermore, the microgrid operator can choose from several options, among which the option to enter into a Purchase Power Agreement (PPA) with the DISCOM. This is where energy can be exchanged according to a pre-set pricing mechanism. This option is a huge step in ensuring the security of investment for microgrid operators. However, it is not very attractive for the DISCOM. It now has to deal with a large number of different microgrid operators, when they are expanding their operations (which are unsustainable to begin with). Part of the problem is that the PPA, as proposed, is a very static agreement, in a system that is in constant flux and change. Every time the system changes, because more solar panels are installed, the agreement must be changed and renegotiated. An undoable job for the DISCOM that is already flooded with ineffective operational processes. Apart from that, the DISCOMs are reluctant to connect their already fragile systems to the alien systems of microgrid operators, making grid balancing another issue that they need to be worried about. All together, it seems understandable that DISCOMs don't show a lot of willingness to work with microgrid operators. This poses as a real barrier to further integration of the electricity system.

A technology called Blockchain, that became known to the larger crowd with the launch of Bitcoin in 2008, promises to revolutionise the way the world works. Blockchain is to Bitcoin what the Internet is to Facebook. It is the decentralised platform behind Bitcoin that allows for easy, transparent, trustable and secure transactions. Easier transactions, that theoretically would also apply to sharing of energy. Would a technology like that prove the solution to resolving the reluctance of DISCOMs and microgrid operators to work together and therefore speeding of the development of energy access to rural areas?

Blockchain is seen by many as 'the next Internet', referring to the sudden intrusion of the Internet in traditional business models. In that sense, they are right. However Blockchain is fundamentally different from the Internet, where it is actually a potential solution to the many problems that still lie in the use of the Internet. Issues such as privacy and security have become a frequent part of our lives. Blockchain gained global attention through the success of Bitcoin, that sparked interest because of the global financial crisis. Bitcoin is a form of a Blockchain, though many more shapes exist.

Essentially, every Blockchain is a ledger, which is a tool used by accountants, that is approached in a distributed way. Depending on the nature of the Blockchain, which we will not discuss here, a 'block' will be created at a certain point in time, thereby giving it a timestamp. In this block, sets of value transactions can be stored and that way later also verified. Each new block is dependent on the transaction in the past, therefore virtually linking all blocks, creating a 'Blockchain', that is stored and accessible distributedly. This would mean that the transaction cannot be changed, without needing to change the following blocks too. This is the reason why this is such a secure way to do transactions, because hacking it would require to adjust the whole blockchain in any place that it is stored, which is every computer connected to it in the network. It is simply impossible with today's computational power to do this (currently discussions are taking place on what would happen when quantum computers are introduced).

This means, that the Blockchain can be used in transactions of value, where parties do not necessarily have to trust each other. This is because the system, or algorithm has this trust embedded in its design. This is revolutionary in our current world, where we rely on third parties such as banks, to verify our transactions. However, the implications of Blockchain do not limit themselves to the financial world. Don and Alex Tapscott show how the Blockchain relies on seven design principles: Network Integrity, Distributed Power, Value as Incentive, Security, Privacy, Rights Preserved and Inclusion. This is relevant for financial services, but also for many other industries such as energy, healthcare, insurance and even governments. An example of Airbnb, paraphrased from Don and Alex Tapscott,

reveals what this means when applied in a distributed infrastructure: *'dAirbnb (distributed Airbnb) is an app on the blockchain where you can put your room online for rent and rent other people's rooms according to your specifications. The user experience is exactly the same as Airbnb, working with reputation systems to validate a user's experience with the renter and vice versa. However it has an important difference. Your information is not stored in a database owned by dAirbnb. The messages between you and your potential renter are only accessible to the two of you giving you full control of your data, inaccessible by third parties.'*

So these decentralised applications (dapps) can have an enormous impact on security and privacy. However, the Bitcoin Blockchain does not allow its infrastructure to be used for these kinds of applications. Examples of Blockchains that can do this are Ethereum and Nxt. Currently hundreds of projects are spawning from the ground as mushrooms, trying to come up with decentralised solutions to many problems. Dapps such as uPort want to create a digital identity on the Blockchain, where you are the owner of your data, not facebook. Wetrust is building new forms of lending and insurance circles (also known as ROSCAs), allowing financial services to be reached by the poor. It is argued that the United Nations even need the Blockchain to reach the Sustainable Development Goals and has now put them on the agenda. The term that captures the infrastructures built on top of the Blockchain is 'smart contracts'.

However, not all Blockchain startups are revolutionising. Gideon Greenspan, CEO of the company that made the Multichain Blockchain, has given the 8 principles to which a project must comply, before inserting Blockchain in the formula really has value. Another article by Jamie Burk (@jamie247), one of the investors of the first Blockchain venture capitalist, gives a different perspective, with some parallels. Jamie Burk finds that often Blockchain companies are just technology looking for a problem, instead of the other way around, as Greenspan also mentions. He has taken up a new approach, where only companies that are 'Blockchain+' will be invested. That is, companies that use Blockchain as a foundation for other technologies, rather than as an end goal. Think of Blockchain being the foundation for Artificial Intelligence, letting it make secure transactions governed by smart contracts. This is a vision incorporated by the Convergence movement. This movement gives a number of key industries in which Blockchain+ can have a facilitating role to revolutionise current practices:

- Industry 4.0
- eGovernment
- Health
- Smart Cities (inc. Energy)
- Mobility Transportation
- Embedded Services

Energy can therefore play an important role in the emergence of Smart Cities. The energy industry is waiting for a major breakthrough to happen, since the current infrastructures and operation protocols are already decades old and therefore in desperate need of rethinking. Also new innovations in energy technology are creating new problems that can be solved by Blockchain. The inclusion of intermittent renewable energy sources in the system could imbalance the grid when their share in it becomes larger. Here, Blockchain allows for a better, secure and efficient way of trading energy.

The first question is: '*How does the electricity market work now and does Blockchain change these operations*?' Now the activities of utilities literally consist of sending around excel files with data on transported and traded energy. There is one single database owned by the utility, which needs to update this data constantly with input from its energy suppliers and customers. In our traditional energy grids, with static central generators such as coal plants, this is largely manageable, since energy use can be scheduled and the required energy can be accordingly generated. The time consuming task of getting input from all stakeholders is therefore a concern, but no drama. Still, the system is vulnerable to (human) errors. Figure G.1 shows a typical flow diagram of information and currency exchanges that the energy market has. For a more detailed description, see Sey Fabode's article, where this image was taken from.

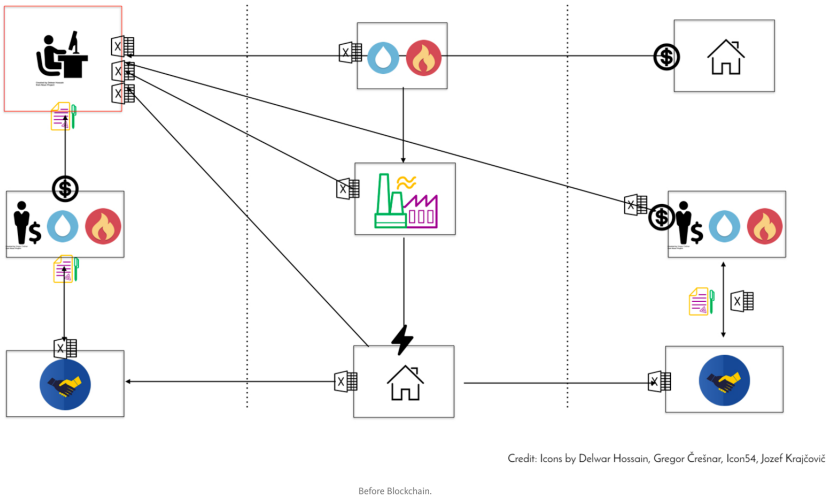


Figure G.1: Traditional Energy System (source in the image)

However, a problem that will show itself in the near future, is the widespread inclusion on varying energy sources, such as wind and solar. For example, due to the appearance of an unforeseen cloud or a drop in wind speed, the energy supply suddenly goes down. This is something that can never be scheduled in by weather forecasting. The problem is that our current grid operations do not allow for dynamic activities on the grid to be happening in real time, because of the way that information and currency flows have to be managed by the utility and its stakeholders. Furthermore the imbalance of energy in the grid can be harmful and needs to be levelled with voltage and frequency controls, but therefore the control system needs information too.

Blockchain has opportunities to improve efficiency in the balancing of the grid, disaster management, dynamic pricing and accountancy. In a Blockchain environment, every stakeholder works from the same ledger, can write its inputs in real time and as Fabode says: 'Everyone's life becomes easier…' Utilities, customers and independent generators would be able to set in place dynamic smart contracts, contracts that can vary according to specific conditions, such as differences in demand and supply of energy, creating a dynamic pricing system.

For example a biomass plant owned by a farmer in rural India could start delivering the backup power to the grid as soon as the central grid fails, for a price that may vary dynamically according to the rest of available energy in the system. If the blackout is during the day, many solar panels would also be able to cover the load, however, at night, the biomass plant operator has a better leverage to sell his energy for a higher price. The market dynamics of supply and demand could all be automatically contracted within a smart contract blockchain environment. Figure G.2 shows how this would be compared to the former situation.

So now we have seen the impact of blockchain on the electricity system, but will this really allow more people to be connected to the grid in India and taken out of energy poverty? Would this also allow for financial inclusion and wealth creation?

Currently the instalment of microgrids for the very poor have somewhat staggered in the country, because of increasing difficulties in keeping the projects commercially viable, despite of plummeting solar energy prices. Some reasons for this are energy theft and billing issues, where often payments are still being done by going door to door due to lack of people with a bank account. However an important problem is also the probability of the central grid extending to the area. Microgrid operators would lose their investment, because the often state-owned and subsidised distribution company (DISCOM/utility) simply installs a connection with cheaper electricity. In response to this, the Government of India has included an option in the latest policies that the DISCOM should come to an agreement with the

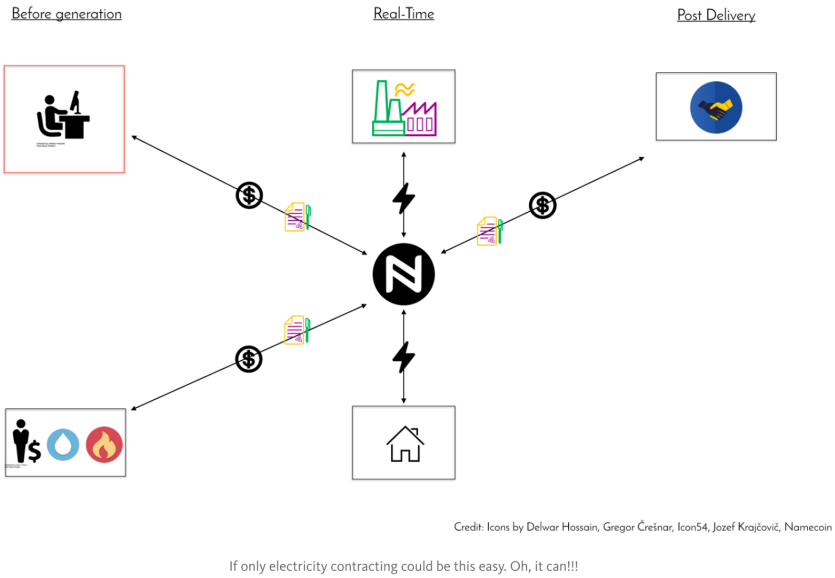


Figure G.2: New Energy System (source in the image)

microgrid operator. It has to take over its assets for the current booking value, while giving the option of setting up a Purchase Power Agreement (PPA).

This PPA would allow the transfer of energy between the parties according to preset prices. However, the agreement is static and must be renegotiated with every change in the topology of the system. Furthermore it doesn't allow for dynamic pricing, what could come to a serious benefit of the biomass plant farmer. So this is exactly where Blockchain comes in. It will facilitate a more dynamic and flexible agreement between the DISCOM and the microgrid operator. Blockchain in combination with smart meters allows the microgrid operator or DISCOM to do electronic billing, which is now mostly done by visiting villagers and physically checking the meters. Surpluses or shortage can then automatically be traded between the DISCOM and microgrid operators, creating an energy trading platform. Furthermore it could even empower independent electricity generators, like rooftop solar owners, to become the owner of the electricity that they produce, by providing the platform to freely share this with others, instead of letting letting the microgrid operator do the trading. Blockchain could completely democratise the energy trading system.

This is not the only benefit, since the operations of DISCOMs that would apply such a system internally would also become much more efficient. This would be another step in the right direction of making them healthy sustainable organisations, which article 1 showed is not the case now. Another large benefit would be for the governmental entities that want to monitor parties such as DISCOMs and microgrid operators, decreasing the chance of corruption. With a distributed shared ledger, the transactions are much more transparent and easily collectable for accountancy and monitoring purposes. All these benefits together can make the operations that are currently required for rural electrification significantly more efficient and therefore more reachable for rural customers that live on a scarce budget. On the other hand it will mean a benefit for the Government, which means a strong incentive from their side to apply such as system. The image below shows a larger view of the possible applications in grid networks.

While creating this smart energy system of the future through Blockchain, the energy network could also pose as an 'anchor for a smart city', as Shalabh Srivastava, Principal Director Accenture India, said recently at the India Smart Grid Week 2017. The whole range of the possibilities that Blockchain technology possesses could become more reachable if all energy expenses were done through a digital currency platform, allowing smart cities to emerge. Since rural households spend between 5 -20% of their income on energy, this would mean a paradigm shift in the way they do transactions. Think about Blockchain based insurance contracts, between solar panels owners or microfinance possibilities for loans to create businesses.

There are, of course, also other sides to the story. One of the possible setbacks could be that there needs to be a large roll out of expensive smart meters connected to the Internet of Things, which will be the topic of a future article. Smart meters are currently still expensive and the upfront costs are too large for the rural villagers. It is still a question if this upfront costs is worth it for the DISCOM or microgrid operators and must therefore be researched. Also the infrastructure to make them communicate is mostly not present in rural areas. Furthermore, as with every product, you cannot simply expect people to accept your 'solution to everything'. The use of the product and its incorporated values must be aligned to how the users look at it, otherwise it will never catch on. An idea would be to make complicated technologies as Blockchain the least visible as possible. However, how would you persuade a solar panel owner that he can freely trade energy with his neighbours? How do we even know he wants to trade energy with them?

It is clear that from a technological point of view, many problems can be eradicated by Blockchain. However this doesn't immediately solve the social problems that lie in the way of electrification. Still, Blockchain can also allow more social based solutions to work, by building digital secure environments where communities can do transactions among each other as is being done in New York. All together the potential for the technology is used, but it cannot be adopted if there is a widespread consensus among policymakers, regulators, technology leaders and other stakeholders that need to collectively adopt the Blockchain environment, before it can reach its full potential.

H

Energy Bazaar - A new organisation in the innovation system

The large number of experiences that have been gained during this research are at the foundation of a new project. With the help of the Responsible Innovation Systems framework, which shall be extended with the Quintuple Helix, a new approach is taken towards increasing energy access, democratising energy ownership and maintaining sustainable and responsible innovation.

During one of the field visits to the rural parts of India, first-hand experiences were obtained in where the problems lie. There was a farmer and he had invested in a rudimentary but pragmatic irrigation system powered by 6 big solar panels. Upon asking what happened to the energy when he was not using his irrigation system, the man frowned and discarded the thought of utilising it for something else. The solar panels were meant to power the irrigation system and he was not considering to use it for something else. At least he did not know that. Meanwhile, neighbours were lighting their kerosene stoves to prepare dinner...

Energy Bazaar aims to replace these kerosene stoves with the excess energy left from solar panels of households, such as of this farmer. This will be realised using a transparent, trustable, and easy to adapt local energy exchange system. The deployment of the project would help cater the rising demand of the millions of Indians, where their income will soon allow for significant energy consumption. In the context of the Paris agreements and the energy transition to sustainability, these people will play an important role in combating climate change and maintaining the progressive march into a better future.

We believe and thus aim to realise that access to energy should be a right. It spawns organisation, collaboration and education. The responsibility for guiding those who are on the verge of energy-access into sustainable consumption lies not only with the farmer, the blacksmith and the nurse in rural India. It also lies with the government, the academic and the industrial sector. Thus, energy bazaar comes into the picture of bringing them all together.

Energy Bazaar concludes that the following 3 pillars to electrification should be followed to solve current days energy problem, while creating future's systems:

1. Increase energy access
2. Democratise energy ownership
3. Maintain Sustainable Innovation and Development

Because of the decreasing costs for solar panels and rapid adoption of technology, consumers will become 'prosumers'. They should be allowed to trade their energy for a fair price on a transparent marketplace. This is the platform what Energy Bazaar wants to provide: easy access by allowing anyone to join the trading platform and helping operators to become more efficient, so they can connect more people; democratisation of the energy sector by creating a decentralised platform for all involved

parties on the energy market through blockchain technology; ownership by creating the possibility for everybody to trade their generated energy on the platform using smart-meters; sustainable innovation through the use of a self-developed framework. Energy Bazaar will use Blockchain technology as an infrastructure to trade electricity, while also creating algorithms for a game-theoretical approach to a market mechanism, as well as optimisation for grid operators. This means there is an incentive to all stakeholders in the innovation system, even government parties, because of a better insight of usage patterns.

As an integrated part of Energy Bazaar's activities, the self-developed framework is used, which is composed of elements from the innovation theories of Systems of Innovation, Quintuple Helix, Open Innovation and Responsible Innovation and builds on the framework created in this thesis.

For sustainable innovation to happen, there needs to be a collective innovation process in an open knowledge environment where the institutions of Government, Industry, Academia, Civil Society and Nature are sufficiently included, while they anticipate on future visions, reflect on each of their roles and influence on others, while creating the capacity to respond to changing situations.

The framework itself is still subject to research and is an integral part of the academic sphere that the Energy Bazaar project wants to cover. It is, however, also the aim to contribute to the other spheres by equally generating political, economic, human, social and natural capital, so that sustainable innovation can thrive.

For more information about Energy Bazaar, contact yvo@energybazaar.org or go to the website on https://www.energybazaar.org.

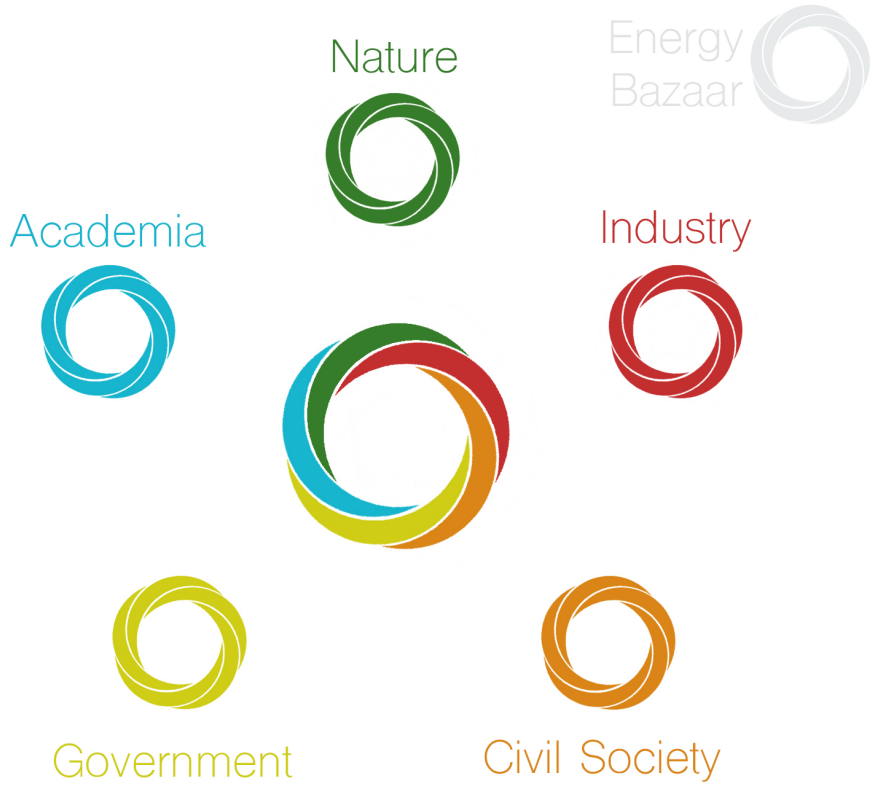


Figure H.1: The logo of Energy Bazaar explained from the Quintuple Helix perspective

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