Towards Energy Resilience for Farmers and Rural Communities in Sweden

Opportunities for New Approaches and Linkages

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Abstract

Purpose: This study aims to explore the collaborative environment needed to support emerging energy innovations in farming.

Method: A qualitative, case study approach has been chosen, guided by an abductive research process. A literature search and interviews were carried out to inform the analysis.

Findings: Following the framework put forward by Glasbergen (2010) on "Partnerships for Sustainable Development" to facilitate the exploration of the phenomenon within the broader context of Agricultural Innovation Systems, the analysis of the case study tends to confirm the importance of trust and shared interests in multi-stakeholder settings, and highlights diverging expectations and goals, and compartmentalisation barriers.

Research limitations and implications: The research focuses on a specific project that hasn't matured yet. The problem could be explored from different analytical perspectives and it would be useful to follow the project until its completion to report on its evolution and assess its outcomes.

Practical implications: Overall, the findings ascertain the need to take a multidisciplinary, holistic view of innovation in farming and support the applicability and further development of the "Ladder of Partnership Activity" framework for understanding the dimensions of sustainability and collective responsibility.

Originality/value: This study examines the overlooked topic of energy dependence in farms and rural areas, and reveals that there is lots of potential to further our understanding of innovation journeys and reinforce the role of innovation networks and partnerships in agriculture.

Keywords: Sweden, farms, resilience, energy, innovation, collaboration

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Abbreviations

AIS	Agricultural Innovation System
AIES	Agricultural innovation ecosystems
AKIS	Agricultural Knowledge and Innovation System
BESS	Battery Energy Storage System
EU	European Union
HES	Hybrid Energy System
HRES	Hybrid Renewable Energy System
MAIS	Mission-oriented agricultural innovation systems
MIS	Mission-oriented innovation systems
MG	Microgrid
SDG	Sustainable Development Goal

1. Introduction

This chapter introduces the notion of multifunctionality of the farm and the need for environmentally friendly, resilient energy systems in rural areas. It presents the general problem, aims and objectives of the study.

Sustainable food systems have been defined by Hebinck *et al.* (2021:17) as "systems that have positive and equitable outcomes on all aspects of its environmental, social and economic dimensions". This entails that such food systems do not operate in a vacuum or isolation from other systems and various stakeholders (Henk Westhoek *et al.* 2016). This also means that sustainable food systems must be resilient, robust to disturbance or shocks, and have an adaptive capacity that allows continuous development (Folke 2016:259).

Farming communities are expected to transition towards circularity, deliver more with less input, ensure food security and do it sustainably, with the least environmental harm, and deal with difficulties resiliently. This sustainability expectation isn't limited to the production stage. Farmers are expected to contribute to the environmental, economic and social pillars of sustainability beyond their primary function (producing food). As Esposti (2012: 247) explains:

> "the agriculture of the future must necessarily be multifunctional, i.e., it must have the ability to produce other non-food goods and services, of public or collective interest, in addition to food".

This can include the use of material produced by animals such as manure for renewable energy. As more electricity is being required to operate in our daily lives, low-carbon backup solutions are key to energy security (IEA 2023). Beyond alleviating environmental problems, the generation of electricity using biomass through self-sufficient Hybrid Renewable Energy Systems (HRESs) such as microgrids (MG) can offer a resilient solution when the regular electricity grid goes down, just when the electricity is most needed not only for the farm but also the surrounding rural communities.

In keeping with the notions of multifunctionality and sustainability of the farm (Esposti 2012) and taking advantage of the biomass inedible for humans (Van Zantem *et al.* 2019), new self-sustaining energy systems for the farm could be developed to mitigate disturbances in the larger electricity grid and provide a systematic and comprehensive off-grid solution for agriculture and rural areas in times of crisis.

The development and uptake of such energy systems raise a few questions linked to the support and assistance needed to achieve such sustainable energy systems for farms and their surrounding community. In particular, it raises the importance of partnerships between different actors and the interaction between different institutions and organisations in rural areas in promoting innovation and collaboration. What favourable context can facilitate agricultural energy innovation? What kind of multi-stakeholder collaboration happens? What are the knowledge and innovation systems at play? And more importantly, are they fit for purpose?

1.1 Problem Background

1.1.1 Rural Areas and the Impact of Power Outages

Transitioning to renewable energy in rural areas is critical for several reasons. Not only do we need to restrain our consumption of fossil fuels and address the challenges of greenhouse gas emissions, but we also need to become more resilient to political or humanitarian crises affecting energy supply and prices (Alhijazi *et al*. 2023). The ongoing war in Ukraine and the COVID-19 pandemic have also highlighted how food and energy production, as well as their supply chains, can be vulnerable. Decentralised, renewable energy production through microgrids would continue to produce energy in times of crisis regardless of the main electricity grid perturbations. Furthermore, the idea with microgrids in rural areas and especially on farms is that the components of the system could be controlled on-site and would not need to be as connected. This would strengthen cyber security.

It is not only food that is produced in rural areas but renewable energy is also produced. For example, dairy farms not only produce milk but can also better manage manure so that it doesn’t become a waste disposal and environmental problem (Van Zanten *et al*. 2019). One solution to address animal waste issues is the transformation of slurry into energy by implementing biogas plants in livestock farms.

However, when the regular electricity grid does not deliver, smaller electricity production units which are still reliant on the main grid, shut down, such as solar panels, wind turbines and biogas plants. With decentralised microgrids, the power outages of the main electricity grid would not impact so many farms, rural residents and businesses and a restart would be easier. For example, in the case of a dairy farm with a biogas plant, sustainable energy production would be maintained and promoted even if the main electricity grid were disrupted.

Let us not forget that the effects of a power outage can generate major economic losses for a farm and can cause animal suffering. For example, feeding machines can no longer feed the animals, milking robots cannot milk, refrigeration systems cannot keep the milk cold, and ventilation systems stop working. Therefore, farmers must have a sustainable contingency plan which goes beyond the conventional, non-renewable diesel generator.

1.1.2 Hybrid Renewable Energy Systems (HRESs) for Agriculture

Konstantinou and Hredzak (2021) describe Hybrid Energy Systems (HESs) as bringing together different generation storage and consumption technologies in a single system. That way, the energy system is not dependent on a single source but combines multiple energy sources. Such systems have been originally designed as a combination of conventional, non-renewable generation (diesel generators for example) with Battery Energy Storage Systems (BESSs).

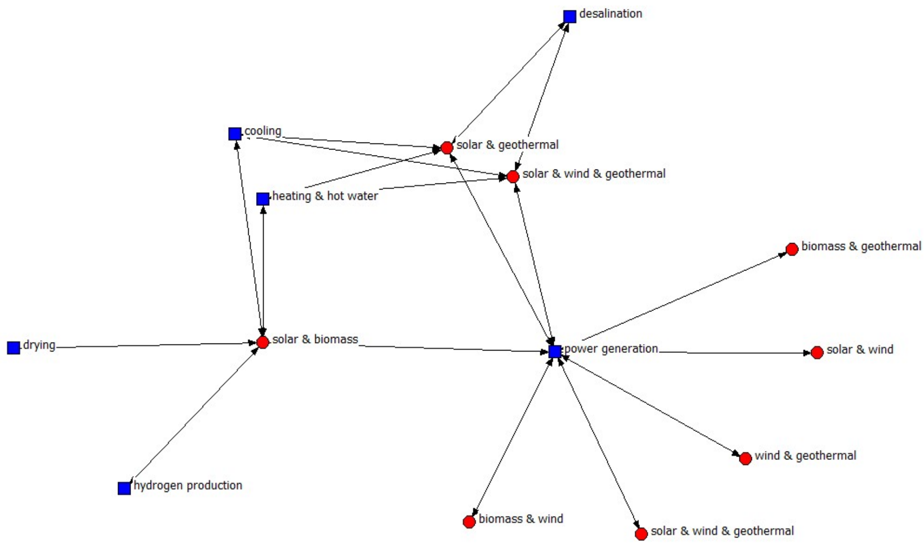

Figure 1 Examples of different hybridisation systems and their outputs (inspired by Guo et al. 2018)

Nowadays, HESs include systems that are based on renewable energy (solar, wind, geothermal or biomass, as illustrated in Figure 1 above), and combine different energy storage systems (BESSs, fuel cells and supercapacitors) for heating, cooling, drying, desalination, hydrogen or power generation. HESs have also grown from small, off-grid systems to larger megawatt systems. They can represent a sustainable and self-reliant power solution for microgrid systems in rural areas where energy supply infrastructure is often weaker.

Self-sufficient HRES microgrid projects can be found in isolated or remote areas (Guo *et al*. 2018). These systems have so far been commercialised mainly for housing, office buildings and industrial companies. However, such systems haven't been rolled out comprehensively in agriculture. There are some examples of farms in Australia with HRES microgrids relying primarily on solar photovoltaic, however, this is not a fully suitable solution for Sweden where there isn't enough sunlight in winter. However, biomass-based hybrid energy systems could provide a cost-effective and environmentally friendly solution for off-grid electrification (Amjith & Bavanish 2022).

1.2 Aim and Objectives

This thesis will explore the enabling collaborative framework that supports farms in Sweden to be innovative in taking up self-sufficient fossil-free microgrids.

Based on an ongoing case study, this project intends to shed some light on the development of partnerships between different organisations and institutions in the Swedish Agricultural Innovation System.

Relying on the general idea of system innovation and the generic concept of interaction, this research project aims to contribute to theories of innovation process and networks by addressing two questions:

(i) Is the existing innovation collaborative system adequate to reach the goal of energy resilience for farms and rural areas?

(ii) What needs to be changed or even transformed in the innovation system?

1.3 Project Outline

Chapter 1 has given an overview of the problem and the purpose of this project. Chapter 2 will introduce the theoretical framework used to explore the phenomenon and map out the analysis. While general theories of innovation processes and systems will be presented, a particular focus will be given to the notion of partnerships. Chapter 3 will set forth the methodological approach conducted in this project, based on qualitative research. Chapter 4 will present some empirical background to better understand the innovation context in the agriculture sector in Sweden and the specific case under study. Chapter 5 will then outline and analyse the results. Reflections, connected to the theories, will be discussed in Chapter 6. Finally, Chapter 7 will conclude the project with possible recommendations and implications for future research.

2. Theoretical Framework

This chapter gives a short introduction to theories of innovation, with special attention to knowledge and innovation systems in agriculture, and presents the notion of partnerships for sustainable development that will frame our analysis. This chapter provides the overarching initial theoretical frame for the research.

2.1 Theories of Innovation in a Nutshell

First of all, what is the meaning or definition of innovation? The term "innovation" can refer to a result of a process (Fieldsend 2020). According to Trott (2021:15), innovation is not only the conception of new ideas, albeit it is a good starting point, but it is also a process that combines the development of something tangible (whether a product or a process), as well as its commercial exploitation.

Multiple models of the innovation process have been developed. Innovation can be described as a "way of achieving sustainable economic growth of organisations and society" (Dieter & Schmitt, 2018: 64). In their book, Tidd and Bessant (2009) highlight that the innovation process and its outcomes are shaped by internal and external influences. In other words, the capability for innovation requires a favourable context (Trott 2021). Innovativeness can be indeed facilitated by external factors such as a well-functioning economic, political and social framework, from favourable laws and regulations to institutions for example. Strategic alliances, partnerships and networks between firms, public bodies, civil society organisations etc. can also boost innovation systems' performance (Klerkx *et al.* 2012; Drottberger *et al.* 2022).

A study from Blix Germundsson *et al.* (2020) also calls attention to the increasing need for open innovation involving collaboration between actors to handle the complex world of VUCA (volatility, uncertainty, complexity and ambiguity). Against this backdrop, new relationships, cutting across organisational, sectoral or disciplinary boundaries matter more and more (Mulgan 2007). Sectoral systems of innovation and production are therefore necessarily multidimensional, integrated and dynamic (Malerba 2002).

Moreover, multiple theoretical approaches have been developed over the years in innovation and sustainable transitions (Warneryd *et al*. 2020). In particular, sustainable innovations should make use of all possibilities offered by the incumbent system to diffuse progressively on the market and ultimately transform the existing socio-technical configuration (Schot & Geels 2008; Smith & Raven 2012). Geels and Schot (2007) have developed a typology of multiple transition pathways (transformation, reconfiguration, technological substitution, or de-alignment and re-alignment pathways), which may be used to describe an innovation and the systemic changes brought about. However, it is recognised that this typology cannot be interpreted rigidly, nor does it address how emerging innovations can struggle against the incumbent system:

> (…) sustainability transitions are necessarily about interactions between technology, policy/power/politics, economics/business/markets, and culture/discourse/public opinion. Researchers therefore need theoretical approaches that address, firstly, the multi-dimensional nature of sustainability transitions, and, secondly, the dynamics of structural change (Geels 2011: 25).

These transition pathways towards sustainability are not self-evident, they often cut across disciplines and sectors, and go beyond the conventional objective of economic profitability. They bring another social and environmental dimension that may require making choices and trade-offs. They are inherently lengthy, complex processes, involving many actors (Geels 2011). A growing body of literature investigates "transformative change", beyond mere R&D investments and economic growth (Schot & Steinmueller 2018). For some, societal challenges need to be addressed through mission-oriented innovation systems or MIS (Hekkert *et al*. 2020), which take a holistic and multidisciplinary approach.

2.2 Agricultural Knowledge and Innovation System (AKIS)

An example of an innovation system that illustrates complex interlinkages in agri-food systems and the involvement of multiple actors, is the Agricultural Knowledge and Innovation System (AKIS) or Agricultural Innovation System (AIS). According to Rivera *et al*. (2006:588) who reviewed the evolution of agricultural knowledge systems and frameworks, the AIS approach "(…) does point up the overwhelming complexity of a multi-functional, institutionally pluralistic system of agricultural development in an increasingly globalised world". While we use the term AKIS in a comprehensive sense, this model usually describes the exchange of knowledge between actors and the role of supporting services in rural areas in a specific country or region. AKIS has been defined as linking "people and organisations to promote mutual learning and to generate, share, and use agriculture-related technology, knowledge, and information" (The World Bank 2006). The notion of AKIS has also been explained as "a set of agricultural organisations and persons, and the links and interactions between them, engaged in the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilisation of knowledge and information, to work synergistically to support decision making, problem-solving and innovation in agriculture" (Röling & Engel 1991 see OECD 2012:46).

The notion of AKIS can be broad in scope and the concept of AIS, which has evolved in parallel, is more used nowadays. The notion of AIS can encompass different dimensions (socio-technical, regulatory and institutional, organisational and social) and highlight how collaborations or partnerships can support innovations and a new environment in which to examine sustainability transition issues in agri-food and agricultural production systems (Klerkx *et al*. 2012; Spendrup & Fernqvist 2019).

AKIS often involves an integrative model of relationships between three types of actors: farmers, government (agencies or ministries), and supporting organisations or innovation brokers (universities, research centres, etc.). This is not dissimilar to the concept of the Triple Helix of university-industry-government relationships that drive innovation (Etzkowitz & Leydesdorff n.d. see Trott 2021: 58). Carayannis and Campbell (2009) have extended the Triple Helix model and introduced the notion of a Quadruple Helix based on "media-based and culture-based public" within an "innovation ecosystem". The Quadruple Helix concept acknowledges the role of the "public" in influencing innovation processes, thus interrelating knowledge, innovation and democracy.

More recent attention has focused on mission-oriented agricultural innovation systems (MAIS) addressing societal and planetary challenges (Klerkx & Begemann 2020). It is acknowledged that agriculture isn't isolated but cuts across other systems, such as energy systems for example. The concept of agricultural innovation ecosystems (AIES) similarly takes a multifunctional approach to agriculture (Pigford *et al*. 2018). Other authors highlight that while changes are needed to achieve the Sustainability Development Goals (SDGs), different types of farmers need *transformations* (plural form emphasised) of different kinds (Stringer *et al*. 2020). This presupposes not only good governance but in particular, engagement with farmers. Foresight processes for transformative change of food systems are also explored and stress the importance of new networks of actors (Hebinck *et al*. 2018).

2.3 “Partnerships for Sustainable Development” (Glasbergen 2010)

Within the family of innovation and transformation pathways theories, Glasbergen (2010) introduces a detailed theoretical framework, a “Ladder of Partnership Activity” which helps to analyse collaboration over time. The model presented by Glasbergen provides a comprehensive framework for understanding innovation journeys and the role of innovation networks. The theory focuses on “changes that partnerships make in the configuration of public decision-making structures” (p. 1) and “This Ladder is based on the assumption that partnering is a process in which actors restructure and build up new social relationships to create a new management practice” (p. 3). We will follow the Ladder concept in our analysis and the extent to which, within the setting of the specific case study and applicable Agricultural Innovation System, the concerned partnership configuration has been able to proceed on the Ladder to reach its sustainability goal.

First, partnerships are defined as collaborative arrangements in which actors from two or more different spheres (whether government, business or civil society) aim to achieve a sustainability goal. The Ladder concept consists of five blocks or core activities framing the partnership and evolving with time, albeit the progression isn’t necessarily linear and includes many feedback loops. The Ladder also attempts to account for the internal and external interactions of the partnership on all levels of innovation systems, the methods that propulse the partnership forward, as well as what may be influenced along the progression.

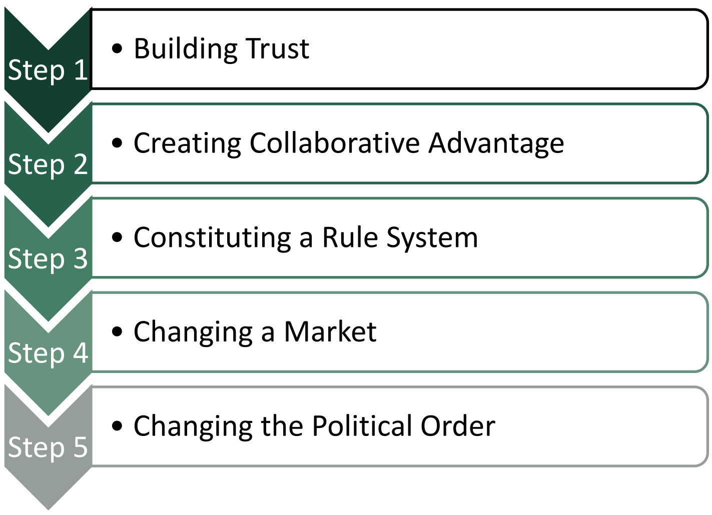

Figure 2 Five core levels of the Ladder concept (adapted from Glasbergen 2010)

As illustrated in Figure 2 above, the first step or critical factor for partnership involves building trust to encourage collaborative interaction and realise added value for all actors. Albeit seemingly straightforward, this is a critical step as the different parties involved may come with divergent or convergent perceptions and values that will frame the collaborative dialogues (Gray 2004; Saville & Adams 2020). Nooteboom (2006) distinguishes in particular between the "Accounting" and "Goal Seeking" frames. The former has fixed objectives and targets, and visible outcomes need to be produced, whilst the latter tries to build a case for change, seek new objectives and is very much based on trust. The former might be considered more economically and technically oriented, the latter more value-oriented (Kojonsaari & Palm 2021).

Trust requires some pre-conditions such as the legitimacy of and respect for the partners (Schruijer 2020). Dialogue and open communication are also essential ingredients to foster mutual trust throughout the partnering process (Swärd 2016).

The second step concerns the creation of a collaborative advantage throughout the process, which can translate as the mutual benefit of collaboration. The special interests of each party need to be fulfilled and realised, whether the objectives are strictly economic, societal or otherwise. Collaboration isn't just a mere exchange but should create new value together (Kanter 1994). This must also be a fair deal, striking a balance between benefits and costs. One of the parties should not take advantage of the collaborative efforts, and this is an aspect where trust building and collaborative advantage reinforce each other (Vangem & Huxham 2003).

The third step consists of constituting a rule system. Once the partners have built trust and developed a reciprocal relationship, formal commitment is required and a set of rules must be put in place. This set of rules can institutionalise new practices or collective responsibility. It can take the form of a code of conduct, a standard or a certification. But it can also take a more prosaic form such as a contract between partners to remedy possible opportunistic behaviour at the expense of others in the partnership (Das & Teng 1998; Woolthuis *et al*. 2005). There must be a genuine link between the initial intentions of the partners and their actual engagement levels. Control mechanisms (such as a legally binding contract) or any other backup structures can be a way of containing the risk of misplaced trust (Lane & Bachmann 1996).

The fourth step is about changing the market. Glasbergen (2010) explains that the rules or institutionalised agreement in the preceding step must be implemented on a broader scale. This is the step on the Ladder where the partners' activities gain recognition and are made mainstream in the market. The notion of legitimacy is important in this step and we will use the institutional approach of Suchman (1995:574) who defines legitimacy as follows: "Legitimacy is a generalised perception or assumption that the actions of an entity are desirable, proper or appropriate within some socially constructed system of norms, values, beliefs and definitions".

The fifth step aims at changing the political order. This means changing the governance system and embedding a "new sense of collective responsibility for sustainable issues" (Glasbergen 2010: 9). Partnerships can have the potential to trigger a broader reflection and "increase the democratic deliberative content of existing institutional arrangements" (Meadowcroft 2007:12).

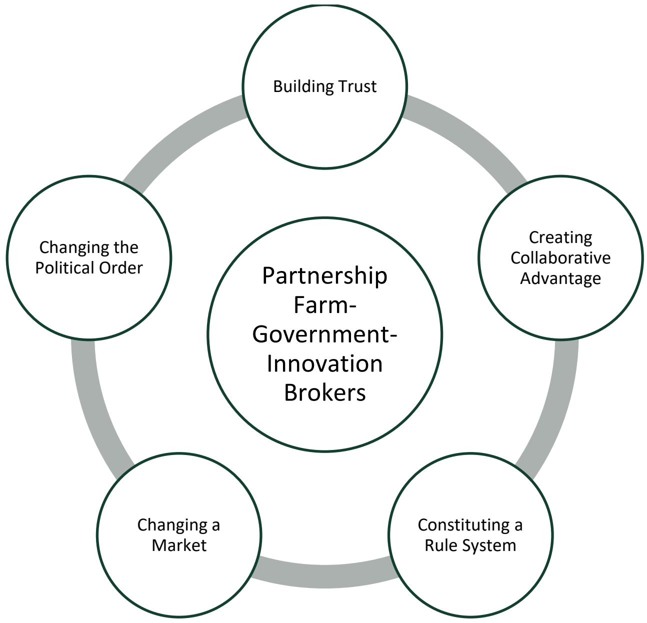

Figure 3 Linking innovation actors and activities in a partnership in the agriculture sector (author's conceptualisation)

As illustrated in Figure 3 above, we will frame our analysis in Chapter 5, based on a specific case study, by looking at the activities of the partnership Farm-Government-Innovation Brokers within the Swedish Agricultural Innovation System. Within the context of the case study, we will particularly explore the management of trust and collaborative advantage. We will also scout how the partnership may proceed and evolve on the Ladder.

Using the model of Glasbergen as our main frame of analysis, we will also draw on the ideas of innovation communities and networks of "promotors" or "champions" presented by Fichter (2009) and Klerkx and Aarts (2013), which emphasise the role of transformational leaders in innovation processes. The contributions of the above-mentioned authors make a distinction between technology, power, process or network promotors (or champions), albeit spillovers between these different categories occur. These ideas complement well the model of Glasbergen in the context of Agricultural Innovation Systems in grasping innovation support systems at different levels, from the farm to the policy levels.

3. Method

This chapter introduces the qualitative approach to the study, the scope and delimitations and quality assurance applied, as well as the ethical considerations of the study.

3.1 Approach

The approach in this study is guided by the work of Robson and McCartan (2016) on "real-world research". The proposed study endeavours to "examine personal experience, social life and social systems, as well as related policies and initiatives" (Robson & McCartan 2016: 3). The proposal's methods also draw inspiration from a study by Mark-Herbert *et al*. (2023).

In this project, we have chosen a qualitative type of research approach through a case study, which focuses on Agricultural Innovation Systems (AIS) in the context of the bioeconomy, and more specifically the potential implementation of HRES microgrids in Swedish rural areas. Informal discussions with a dairy farmer in rural Småland in Sweden inspired the study. Case studies can help to better understand the complexity of a particular phenomenon in context and provide the basis to develop concrete knowledge as well as a test or generate theoretical analysis (Flyvberg 2006:229; Robson & McCartan 2016; Bell *et al*. 2022). As put forward by Sutherland *et al*. (2023:60) "to understand how farmers innovate, (…) it is important to start from farmers' perspectives".

The methodological approach is neither inductive nor deductive as such but follows an abductive process. We are not proposing any original theory, nor are we testing an existing one as in quantitative research. Rather we are seeking the best explanation through an iterative process of continuous reflection between possible different theories, the data we have gathered and guided by our personal value system (Bell *et al*. 2022). The different theories looked into (see Chapter 2 above) and in particular the conceptual framework proposed by Glasbergen (2010) provide the overarching frame to facilitate the exploration of the phenomenon under study.

In the first phase, it has been necessary to study literature to get a deeper understanding of the problem and the possible applicable theories to be able to carry out the analysis. A literature search has therefore been conducted aiming at (i) informing the empirical background on HRES microgrids, (ii) developing the theoretical framework on innovations and (iii) presenting in particular agricultural knowledge and innovation systems (AKIS). Electronic databases such as Web of Science (WoS, all collections) and Google Scholar were searched. The search included search terms such as “agricultural knowledge and innovation systems” and “AKIS”. Terms including bio-based, bioeconomy and Sweden were also searched.

The PICO (Problem Intervention Comparison Outcome) technique has also been used to inform the literature search strategy. This technique helps to apprehend the articles’ overall contributions better. The idea is that the contributions from the different selected studies should serve as a basis to explain the context of the study, identify further reading, elaborate on the theoretical focus, and later structure the analysis.

In the second phase, a flexible analytical approach for qualitative content analysis was carried out, based on interviews, discussions, and email correspondence, as well as document analysis of internal (project plan) and external materials (such as reports, for example). Interviews have been conducted using semi-structured questions adapted to each stakeholder, following a three-stage process (adapted from Granot *et al*. 2012):

(i) Context description (why? how?),
(ii) Actual experience (what?), and
(iii) Reflection (next steps?).

An outline of some of the questions asked to the experts can be found in Appendix 1. Some interviews were conducted in person, others by telephone or using Zoom video conferencing software. They were also followed up by email correspondence. All interviews and discussions were reported in personal notes and kept confidential. They were not recorded and transcribed verbatim to keep an atmosphere of genuine dialogue in the specific setting they occurred.

3.2 Selection of a Case Study Unit and Interviewees

A dairy farm in Småland is the geographic setting of the empirical part of the study. Different stakeholders are involved in the development of HRES microgrids. The following actors (a total of 9 experts), capable of giving rich and detailed answers due to their specialist knowledge or direct involvement in the project, have been contacted and interviewed about their experiences and perceptions:

Actors directly involved in the case study:

- Dairy farmer

- Hushållningssällskapet or the Rural Economy and Agricultural Society (advisory service or intermediary organisation)
- Jordbruksverket (Swedish Board of Agriculture, a governmental agency)
- Stiftelsen Seydlitz MP Bolagen (funding organisation)
- Swede Energy Empowerment AB (consultancy services in the energy domain)

Actors contacted to "contextualise" the problem for background purposes:

- Energimyndigheten (Swedish Energy Agency, a governmental agency)
- RISE (Research Institutes of Sweden)

The Swedish Parliament was also contacted via email to discuss the follow-up of a report and a new legislative proposal on energy issues put forward by the government.

Case study analysis

Following the literature search and the interviews, and while guided by the conceptual framework presented by Glasbergen (2010), a flexible analytical-qualitative approach has been carried out, identifying themes and enabling factors, and involving the following general steps (Robson & McCartan 2016: 469):

i. Identification, collection and familiarisation with the data,
ii. Identification of common themes and factors linked to the theoretical framework,
iii. Exploring similarities, patterns or relationships, and
iv. Interpretation and presentation of the results.

One of the risks in qualitative research and a theoretically-based analysis can be to seek data which are consonant with the theory (Robson & McCartan 2016). In this research project, whilst the analysis is structured by the conceptual framework put forward by Glasbergen (2010), we have tried, as far as practical, to use multiple sources (interviews, documents) and consider different perspectives and theories (see Section 3.4 below on quality assurance).

3.3 Scope and Delimitations

The research study is limited to a specific unit of analysis, a dairy farm in Småland, and the interviews of the stakeholders directly involved in its innovative microgrids project or with specialist knowledge on the issue. The intention of the study is not to achieve an exhaustive account of knowledge and innovation systems in Sweden, nor a template to follow on how to apply for funding of HRES microgrids. Moreover, the study is not so much concerned with the technology itself. Neither does the study intend to evaluate the bioeconomy or energy policies, laws and regulations, implemented or not in Sweden. The study rather intends to possibly give some good practices and potentially highlights some challenges and opportunities in Sweden's knowledge and innovation systems when it comes to the uptake of HRES microgrids in the agriculture sector.

3.4 Quality Assurance and Ethical Considerations

Continuous reflection in the collection of the data, analysis and reporting has endeavoured to ensure as far as possible credibility, dependability and authenticity of the study. The elements presented in Table 1 below, have been paid attention to.

Table 1 Importance of trustworthiness: a checklist (adapted from Riege 2003 and Elo et al. 2014)

Phase	**Ensuring trustworthiness Elements to pay attention to:**	**Intended accounting applied in this study:**
Preparation phase	Data collection method Sampling strategy Selection of a suitable unit of analysis	Multi-stranded approach: different sources of evidence are used as far as possible and interviews are carried out Ethical considerations A dairy farm in Småland is willing to participate and share information
Organisation phase	Categorisation and abstraction Interpretation Representativeness	Themes are developed as data is collected and revisited to ensure as much as possible relevance The project seeks to explain the findings in line with the theoretical concepts The project strives to define the scope and boundaries

Reporting phase	Reporting results Reporting analysis process	Connections between data, results and theoretical concepts are sought

The elements presented in Table 1 above have been important during the preparation, organisation and reporting stages of the research project, with an emphasis on methods of sampling, data sources and collection, and data analysis. Taken together, these elements endeavour to give an indication of the trustworthiness of the study (Elo *et al*. 2014).

Ethical considerations have been followed in this research project. Interviewees were involved with their knowledge and consent. They were informed of the nature of the research, and any quotes in the thesis attributed to their organisation were checked, revised and approved by the participants. Precautions have been taken as far as possible to preserve the confidentiality of the participants and the data collected from them. Complete anonymity could not be guaranteed as the case study on which this research is based is already in the public domain, and it would have otherwise weakened the integrity of the research. The interviewees' personal data have not been shared with outsiders at any time.

4. Empirical Background

This chapter outlines the overall policy context in which HRES microgrids in agriculture operate in Sweden. It depicts the Agricultural Innovation System in Sweden and it describes the idea of the case "Robusta Gården" upon which the study relies. Finally, it sums up our understanding and perspectives on the problem situation.

4.1 Energy Resilience in Sweden

While there appears to be a clear policy in Sweden aimed at increasing biogas production from manure and strengthening the security of the energy supply, there is still a gap to bridge when it comes to enhancing the capabilities of rural energy communities and promoting decentralized renewable energy systems.

Biomass from agriculture

Over 80% of Swedish electricity relies on hydropower or nuclear power. There are long-term plans and investments to increase electricity production using renewable sources such as hydropower, biomass, wind, and solar (OECD 2018). Policies to reduce emissions from the agriculture sector have been on the political agenda for some time now and focus on moving away from fossil fuels, towards renewable energy (Engström *et al*. 2008). Under Ordinance 2014:1528 on State aid for the production of biogas, there exists since 2015 a support scheme for biogas production through anaerobic digestion of manure, partly funded through the EU's rural development programme (Ministry of Climate and Industry 2023). The latest report of the Swedish Climate Policy Council indicates that:

> "To increase the production of biofuels from agriculture, a support scheme is available for biogas production from manure. The scheme offers dual environmental and climate benefits by enabling biofuel to replace methane emissions while serving as a substitute for energy from fossil fuels" (Swedish Climate Policy Council report 2022:74).

Security and self-sufficiency

The EU is promoting decentralised renewable energy systems (Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 Amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as Regards the Promotion of Energy from Renewable sources, and Repealing Council Directive (EU) 2015/652), with the broad aims of creating local energy production and jobs, boosting energy supply security and reducing transmission losses and exposure to price shocks.

Microproducers in Sweden (individuals or businesses investing in electricity production from renewable energy sources for self-consumption) can receive a tax reduction, according to the Income Tax Act (1999:1229) for the excess electricity they feed into the main grid. According to the Electricity Act, micro-producers can also benefit from a reduced energy tax if the generator power is less than 100kW and if the electricity produced is not transferred to a collective system subject to a network concession (Ministry of Climate and Industry 2023).

Following a report on permit processes for electricity grids (SOU 2019:30), amendments have been proposed to the Electricity Act (1997:857) paving the way to expand the electricity grid in Sweden and to make the permit procedures less burdensome (Ministry of Rural Affairs and Infrastructure 2019).

However, the European Commission (2023:6) recently noted that “the draft updated NECP (*National Energy and Climate Plan*) is not sufficiently detailed about the envisaged targets, policies and measures to enhance the security of Sweden’s energy system”, and that information or quantitative objectives on individual and collective energy self-consumption as well as renewable energy communities was missing (European Commission 2023:14).

The Swedish government submitted in March 2024 a proposal to the Parliament (Proposal 2023/24:88 “A clearer process for licensing electricity networks”) “to contribute to a clearer and faster process for renewing, strengthening and expanding electricity networks. The proposal concerns high-voltage power lines that require a network concession for a line, as the permitting process for such lines is longer than for another network» (Sveriges Riksdag 2024). However, the proposal seems to be helpful to large energy players and does not seem to necessarily address energy security in rural areas. It is understood that not enough attention has been given so far to supporting rural areas in energy transition through local participatory governance.

4.2 The Agricultural Innovation System (AIS) in Sweden

The literature usually highlights the following generic actors who contribute to shaping the AIS:

1. Users and initiators of knowledge and innovation
2. Governance bodies
3. Knowledge and research generators
4. Funding organisations
5. Intermediaries organisations or advisory services

Farmers and businesses in the agriculture and food sector are normally the main users and in some cases initiators, of knowledge and innovation. The government plays a key role in the governance and funding of the AIS. In Sweden, regions are critical bodies of governance but have different priorities and as a consequence resources allocated to AIS may be fragmented across the country (OECD 2018). Knowledge and research generators include universities (SLU is a prime example) and various research centres. Funding organisations are mainly public but can also be private and have varying degrees of interest and focus areas in the agriculture sector.

Intermediary organisations or advisory services typically share and disseminate the knowledge between actors. Such organisations or services have been defined as "sets of organisations that support and facilitate people engaged in agricultural production to solve problems and to obtain information, skills and technologies, by enabling farmers to co-produce farm-level solutions by establishing service relationships with advisers" (Ingram & Mills 2018:22). They can also carry out research themselves or act as funding organisations (for example, the Swedish Board of Agriculture, who can be considered an advisory organisation, provides funding; RådNu is also a research centre, and the same applies to organisations such as KFC and CeFEO). There are many such organisations, both of a public and private nature, with cross-functional roles. Some private companies who for instance sell farm machinery and equipment provide advisory services albeit this could be argued to come within the range of their after-sale services (for example the companies De Laval and Leyly). The intermediary organisations can have different functions articulated around demand stimulation, network and knowledge brokering, innovation process management, capacity and institutional building (Kilelu *et al*. 2011).

Table 2 below provides an overview of the different actors, institutions and governance bodies in the Swedish AIS and is not meant to be exhaustive.

Table 2 Overview of the different actors, institutions and governance bodies involved in the Swedish AIS (adapted from OECD 2018)

Industry	Farmers and agri-food businesses
Government	Ministries Regions/County Councils Municipalities
Knowledge and R&D organisations	Universities Research centres - AgriFood Economics Centre (SLU and Lund University cooperation) - RISE Research Institutes of Sweden - Krinova Incubator and Science Park (University of Kristianstad) - Green Innovation Park (SLU)
Funding organisations	Swedish Research Council Vinnova (Swedish Governmental Agency for Innovation Systems) Formas (The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning)
Intermediary or advisory organisations	Swedish Board of Agriculture (Jordbruksverket) The National Food Agency (Livsmedelverket) The Rural Economy and Agricultural Societies (Hushållningssällskapet) Växa Sverige AB LRF Konsult Länsstyrelserna (County Boards) Farm and Animal Health (Gård och Djurhälsen)

	Svenska Foder Rådnu KFC (Kompetenscentrum för Företagsledning) CeFEO (Centre for Family Enterprise and Ownership)

According to the OECD (2018), while the Agricultural Innovation System (AIS) is part of the Swedish Innovation System (SIS), research does not appear to be well linked with the needs of the agriculture and food sectors. The OECD report recommends a long-term strategy to better account for the knowledge and innovation needs in agriculture.

4.3 The "Robusta Gården" Project

The research study focuses on a specific project, "Robusta Gården" or what we have chosen to translate as "Resilient Farm", initiated by a dairy farm in Småland. Meuwissen *et al*. (2019:1) define the resilience of a farming system as "its ability to ensure the provision of the system functions in the face of increasingly complex and accumulating economic, social, environmental and institutional shocks and stresses, through capacities of robustness, adaptability and transformability". The following background draws on discussions held with the concerned dairy farmer, the energy consultant and experts from the Rural Economy and Agricultural Society, and the Swedish Board of Agriculture.

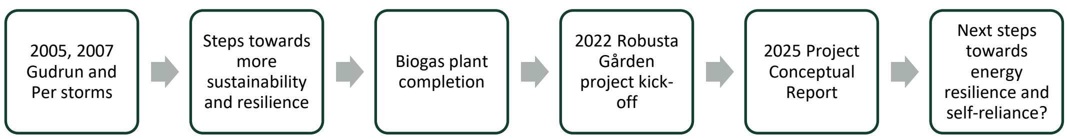

Figure 4 The idea and steps of the "Resilient Farm" (author's conceptualisation)

The initial idea of the "Robusta Gården" stemmed from the aftermath of the storms Gudrun (2005) and Per (2007), as illustrated in Figure 4 above, which knocked out the main electricity grid and occasioned many challenges, beyond the power cuts, for the dairy farm and the surrounding community. The dairy farm and surrounding area were out of electricity for two weeks.

While regulatory initiatives and other structural changes took place to render the electricity infrastructure more robust across the country after the violent storms (Nohrstedt & Parker 2014), it became clear for the dairy farm that a more resilient and sustainable vision was needed. Farms that produce energy should become independent of the regular electricity grid, reducing the strain on the grid while strengthening security and resilience to power outages.

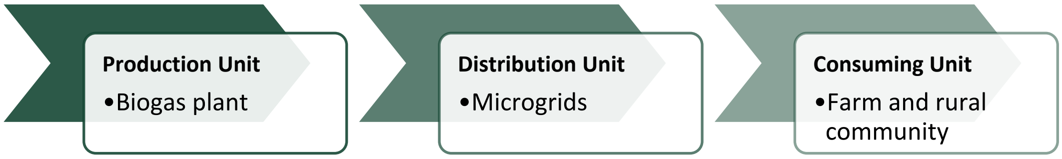

Figure 5 The Resilient Farm concept (adapted from discussions with Swede Energy Empowerment AB, 2024)

The dairy farm has built a biogas plant as a first step but is still dependent on the main electricity grid. As illustrated in Figure 5 above, the dairy farm is now looking into a more comprehensive solution to become off-grid and resilient to crises. In addition to natural disasters, the past years have witnessed different types of crises and catastrophes. The war in Ukraine and the effects of the COVID-19 pandemic have both fragilized the food and energy supply chains and led to an increase in energy prices across the EU. The dairy farm is therefore exploring the possible implementation of HRES microgrids, that could use multiple sources of energy, including biomass, to reduce its dependence on imported fossil fuels, and benefit from fair and affordable prices.

The dairy farm has some 500 cows, and it is estimated that electricity and heat produced by the "Robusta Gården" would have the same capacity factor as any other conventional energy source (nuclear, oil, hydro) and about four times the capacity of solar and wind combined. It has also been evaluated that 10000-kilowatt hours of electricity can be obtained in a year from the manure of 1 single high-producing dairy cow.

The dairy farm allied with an energy consultant to start a study to explore possible off-grid solutions for Swedish farming and together approached the advisory services Hushållningssällskapet, which can translate as the Rural Economy and Agricultural Society and is considered as a knowledge and innovation intermediary actor. In turn, this intermediary actor made an application for funding to the Swedish Board of Agriculture (Jordbruksverket), supported by the European Agricultural Fund for Rural Development which aims to enhance knowledge, cooperation and innovation in agriculture. The Swedish Board of Agriculture published a call for proposals with funding opportunities on "new business models through cooperation" with the overall goal of increasing farmers' competitiveness and reaching out to as many Swedish farmers as possible.

The project “Robusta Gården” is also co-financed by Stiftelsen Seydlitz MP Bolagen (a private Foundation set up by the founding member of the company MP Bolagen). One of the Foundation’s purposes is to support research and education in milk production and animal and feed husbandry.

The idea is that the concerned dairy farm will be piloting the new solution, which can eventually be rolled out to other farms. Further, once up and running, a long-term objective of HRES microgrids for farmers would be to increase the resilience of rural areas not only for farms but also for the nearby households that a “plus-energy” farm could support. In the medium term, the piloting dairy farm plans to install a greenhouse where vegetables can grow and a creamery exclusively powered and heated on the farm and independently from the main electricity grid.

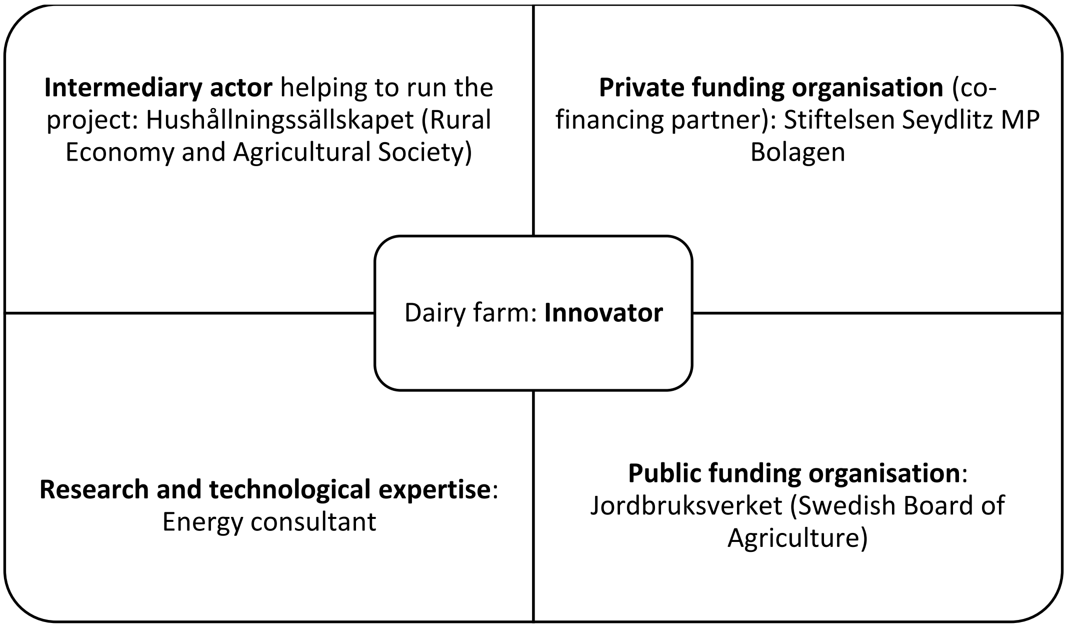

Figure 6 Stakeholders and organisations involved in the case study (author's conceptualisation)

Once a conceptual report exploring and describing different HRES microgrid solutions is ready by April 2025 (Figure 4), a prototype should be developed. Legal and economic aspects of HRES microgrids are also looked into. A communication outreach plan targetting different actors (farmers and other concerned stakeholders such as research or business organisations) is envisaged to bridge the gap between policy and practice. Expected conclusions from the report will include an estimation of the environmental gains and to which extent such HRES microgrids would be legal and profitable (for whom). The different stakeholders and organisations currently directly involved in the project are represented in Figure 5 above.

It is estimated that there are some 67000 farms in Sweden, of which 75% can be considered commercial farms (OECD 2018). There is therefore potential for agricultural companies to become more robust and resilient, as they become less sensitive to price fluctuations of electricity and more independent of the main power grid. The operational disruptions of food production would also be reduced and an increased share of renewable, sustainable energy would be promoted, contributing to climate change mitigation and environmental goals.

4.4 Making Sense of the Problem Situation

Before moving on to the next sections of this thesis, it can be helpful to sum up who are the stakeholders, their concerns and associated issues in the "Robusta Gården" project. Based on the background information presented in the precedent section, and to recapitulate, the following actors are directly involved in the Robusta Gården project: a dairy farm, a private funding organisation (Stiftelsen Seydlitz MP Bolagen), a public funding organisation (Swedish Board of Agriculture), an advisory service for the farm (the Rural and Economy and Agricultural Society) and an energy consultant providing technical advice to both the farm and the Rural Economy and Agricultural Society.

Table 3 below sets forth our understanding and perspectives or *boundary judgments* informing the system under study. Table 3 is based on a supporting tool developed by Ulrich and Reynolds (2010) aimed at appreciating "the bigger picture" and enabling later "reflective practice" in the discussions.

Table 3 Boundary judgments informing our system of interest: the "Resilient Farm" case (adapted from the Critical Systems Heuristics tool by Ulrich & Reynolds 2010)

	Sources of influence	**Boundary judgments informing the "Robusta Gården" system under study**		
		Stakeholders	**Specific concerns**	**Key problems**
The involved	**Motivation**	**Beneficiaries**: *Who is served?* Farmers and rural communities	**Purpose**: *What should be achieved?* Energy resilience, food security, social and environmental welfare	**Measure of improvement**: Take up of suitable and affordable energy technology, easy infrastructure adaptation

	Control	**Decision makers:** W*ho should decide?* Governmental agencies, Farmers and rural communities	**Resources:** W*hat resources should be available?* Financial and political	**Decision environment:** W*hat should be the conditions of success?* Supporting policies in the general interest
	Knowledge	**Expert knowledge:** *Who contributes experience and expertise?* Intermediary service, Expert consultancy	**Expertise**: Technical, legal and financial skills and competencies	**Guarantor**: W*hat would guarantee success?* Collaborative arrangements with other networks
The affected	**Legitimation**	**Witness**: *Who should voice the concerns of those not directly involved?* Governmental agencies and municipalities	**Emancipation**: W*hat will emancipate those not directly involved?* Accessible technology (costs, performance) Political and competitive certainty	**Worldview**: W*hat worldview should we build upon?* Mission-oriented innovation systems and high connectivity between all stakeholders

The tool presented by Ulrich and Reynolds (2010) distinguishes different sources (motivation, control, knowledge and legitimacy) which may influence the different stakeholders in the system of interest under study, their concerns, and the problems to address. The answers in Table 3 above are not right or wrong and are only tentative, based on our questioning and assumptions. The major sources of influence of the “Robusta Gården” system as we see and assess them are as follows: (i) motivation: the objectives of the system are centred on farmers and rural communities, (ii) control: a governmental agency and a private Foundation have provided the initial resources (funding), (iii) knowledge: expertise comes from an energy consultancy and an intermediary service, and (iv) legitimacy: it seems to us that the stated objectives of the project align with an encompassing social, economic and environmental improvement of farming.

Based on this reference system, the following Chapter 5 will present the results where the focus is on how the “Robusta Gården” project has evolved so far on the Ladder of Partnership (Glasbergen 2010) and what uncertainties remain. In Chapter 6 these findings are analysed and discussed. Chapter 7 ends with conclusions and some reflections on the implications for theory and policy.

5. Results

This chapter presents the outcomes of the discussions held with the concerned stakeholders. It is guided by the theoretical framework put forward in Chapter 2, in particular the “Partnerships for Sustainable Development” model.

This Chapter draws on the semi-structured interviews and various correspondence held with the actors directly involved in the “Robusta Gården” project as presented in Table 4 below:

Table 4 Actors directly involved in the "Resilient Farm" project and their main function and role in the context of this study (inspired by Fichter 2009 and Klerkx & Aarts 2013)

ACTOR	FUNCTION	ROLE
Dairy farmer	Beneficiary and Innovator	Original Champion/Promotor
Swede Energy Empowerment AB (Energy Consultant)	Advisory service/Research organisation	Technology/Expert Champion/Promotor
Hushållningssällskapet (the Rural Economy and Agricultural Society)	Advisory service or intermediary organisation	Process/Network/Relationship Champion/Promotor
Stiftelsen Seydlitz MP Bolagen	Funding organisation (private)	Power Champion/Promotor
Jordbruksverket (Swedish Board of Agriculture, a governmental agency)	Funding organisation (public)	Power Champion/promotor

5.1 Pluralistic Organisations and the Importance of Trust

Our research into the Swedish Agricultural Innovation System confirms a European-wide trend of a diverse mix of advisory services and funding organisations, with different priorities, objectives, and delivery approaches (Ingram & Mills 2018; OECD 2018).

The dairy farm involved in the "Robusta Gården" project took the service of the Rural Economy and Agricultural Society, with whom they have a long-standing collaboration. The Rural Economy and Agricultural Society is a well-established intermediary organisation in the agriculture sector and can be considered as an "institutional safeguard" (Swärd 2016:1843). In the project, this advisory service is substantially involved in the innovation process by applying for funding, coordinating the project, etc. It can be considered to have both the roles of network and process promotor (Fichter 2009; Klerkx & Aarts 2013). Still, it leaves the actual technical deliverables (microgrids) to a knowledge expert, an energy consultant. The dairy farm and the energy consultant have also known each other for many years and went through the storms Gudrun and Per together and share the same concerns. Together with the advisory service, they form the core team of the project partnership and partake in a "sense of shared purpose" (Gray 2004:168).

Against this backdrop, finding the right partner and building trust at a project's inception is key. As one of the interviewees puts it explicitly:

> "The Swedish Board of Agriculture certainly made a careful assessment of the project before granting funding, so we "trusted" their assessment and thought that the project had to be secured through our grant" (Stiftelsen Seydlitz MP Bolagen).

Both the authority of the governmental agency and its seriousness in evaluating a project are assumed by the co-funding partner. They "trusted" and respected the agency's assessment (Glasbergen 2010; Schruijer 2020).

Further, both the governmental agency and the co-funding partner can be considered to have the role of "Power Promotor or Champion" since they control the resources (Fichter 2009; Klerkx & Aarts 2013).

According to Woolthuis *et al.* (2005), a distinction can also be made between competence and intentional trust. While the former may refer to professional competencies, the latter may relate to the notions of benevolence and goodwill. In the case study, the trust in the governmental agency may be more of a "competence trust" nature. In contrast, the trust dynamics in the core team may be more akin to "intentional trust" or possibly "goodwill trust", beyond contractual obligations (Trott 2021:270).

Additionally, the geographic closeness is a factor of trust, where potential organisations can feel they have a stake in the project and the rural community:

> “The farm is also in our immediate vicinity” (Stiftelsen Seydlitz MP Bolagen).

As the project “Resilient Farm” cuts across the energy sector, the lack of familiarity with a new funding organisation in the usual AIS landscape, such as the Swedish Energy Agency, has also been a challenge. The Rural Economy and Agricultural Society initially applied for funding with the Swedish Energy Agency to kick-start the project but the application wasn’t successful. Whereas knowledge and trust in the well-known system established by the Swedish Board of Agriculture are instituted, the funding criteria and expectations of the Swedish Energy Agency were less self-evident. Further, while the Swedish Board of Agriculture is accustomed to the challenges and constraints of the farming sector, the Swedish Energy Agency possibly comes across as less experienced:

> “ (…) the Swedish Board of Agriculture has a different approach to prioritising projects. Where the Swedish Board of Agriculture has a set system which we have experience of, the Energy Agency is more novel to us and vice versa they are not familiar with us and our sector (…)” (Expert of The Rural Economy and Agricultural Society).

We understand that the Swedish Board of Agriculture has a point system for assessing project proposals, which are known and communicated beforehand to the applicant. The Swedish Board of Agriculture seems to be keen on the broad picture of the project, asks follow-up questions and requests additional information to help them assess the application. In contrast, we understand that the Swedish Energy Agency may have a different, more formal approach.

5.2 Different Kinds of Approaches to Collaborative Advantage

Collinson and Liu (2018:51) have not only emphasised that cooperative partnerships involve mutual learning based on mutual trust, but are also often driven by a shared interest. The project needs to be relevant to pick the interest of potential partners, whether advisory services or funding organisations and create new value through collaboration (Kanter 1994). As one of the funding organisations articulated:

> “In these times when there is a great focus on self-sufficiency and being able to handle situations when disturbances arise, for example in the energy supply, the Foundation thought that the project was well suited for milk production” (Stiftelsen Seydlitz MP Bolagen).

A challenge in nurturing collaborative advantage is often to convince funding organisations that the project can be profitable and within the remit of their resource capacity. As one of the interviewees explains:

> “ (…) politicians steer the discussions around profitability and money without vision around food and energy security questions. The financing institutes don’t have the money to fund our type of project.” (Energy Consultant).

The above quote illustrates the importance, for the core project team, of creating shared value, as a basic premise for advancing societal and economic progress in the communities (Porter & Kramer 2011:66).

Another key issue identified in this project which also has a bearing on the creation of a new value is the possible compartmentalisation of funding organisations in the broader innovation system. As the advisory service involved in the project explains:

> “(…) some of the agencies routinely regard farm-related projects as none of their concerns. For instance, a large initiative for self-driving machinery funded by two agencies on innovation and business development would not include farm machinery. However, there is a market for automated farm machinery. Similarly, an initiative on AI for the food supply chain started beyond the farm gate. So basically farmers are not involved in initiatives in the food chain. This makes farming business excluded from larger governmental actions towards business growth and innovation” (Expert of The Rural Economy and Agricultural Society).

> “ (…) whereas automated machinery in agriculture has come far, perhaps even further than other sectors, and is implemented in small farming companies, where robots for milking, feeding, and manure management are implemented in day-to-day operations. Early weeding robots are ready to be implemented and we have arranged tech demos for self-driving weeding robots.” (Expert of The Rural Economy and Agricultural Society).

As illustrated in the above quotes, the agriculture sector seems excluded from mainstream or broader food supply chain innovation initiatives. It looks like the sector is seen as a special sector as if operating in a vacuum, cut off from other systems or value chains.

Further, it is understood that discussions with the local municipality and the existing energy company owning the grid have not led so far to any fruitful outcomes. The municipality and the energy company reportedly couldn’t fully come together around the idea within the current institutional and operating environment. As Lane and Bachmann (1996:391) have stressed:

> “Partnership-based relationships are unlikely to arise spontaneously. Instead, they tend to be built on common expectations which are constituted by the institutional environment in which social actors are embedded”.

More will therefore need to be done to get the support of the local municipality and the energy company. This will also depend on a favourable legal context, making it possible for local actors such as farmers to access the energy market on a level playing field with the existing energy actors.

5.3 Control Mechanisms to Consolidate Trust and Collaborative Advantage

For the project to succeed, a formalisation of some kind is needed along the process in which the partners continue to invest in each other (Glasbergen 2010). In the case study analysed, a key output will be the delivery of the inception report in 2025, which hopefully will pave the way for further commitment of each party to the partnership. It is hoped that upon the delivery of the report, it may be possible to secure further funding to realise and scale up the prototype, and possibly partner with the Swedish Energy Agency.

An important aspect of the report will be, beyond the technical aspect, the financial and legal considerations of the project. The microgrids need to be financially viable and also authorised through the right permits.

In the meantime, the Swedish Board of Agriculture monitors and controls the progress of the report. The governmental agency has a responsibility to keep the process to which they have granted money under review and look after the general interest (Meadowcroft 2007). We have been informed that a letter of approval and a formal agreement exist between the funding organisations and the project owner (The Rural Economy and Agricultural Society). This formal or contractual step in the Ladder complements the two previous activities (trust and collaboration) and reinforces the confidence in partners' cooperation (Das & Teng 1998; Woolthuis *et al*. 2005). The project owner needs to implement agreed actions, not least the delivery of the inception report in 2025. We can assume that the agreement may include provisions related to its duration and termination, the payments (several instalments might be planned), the performance of the deliverables and the ownership of the results (intellectual and industrial property considerations); law and jurisdiction provisions may well complete the terms of the agreement in case of disputes. Similarly, a contract has also been drafted between the core team partners to clarify and manage expectations.

5.4 Changing the Market and Transforming Institutional Arrangements, Quo Vadis?

The practical goal of the "Robusta Gården" project is for farmers to invest in decentralised HRES microgrids, and create incentives to transition to more sustainable, self-sufficient energy production. The Rural Economy and Agricultural Society plans to ultimately disseminate the output, which includes a technical solution and guidance material addressing legal and economic aspects of the microgrids, to farmers, agricultural companies, other advisory organisations, energy companies and business promoters, technology suppliers and competent authorities including municipal bodies. The Rural Economy and Agricultural Society also intends a wide-reaching communication strategy involving printed materials, films, participation in conferences, seminars, and trade fairs, the organisation of webinars and study visits, as well as press articles in relevant magazines.

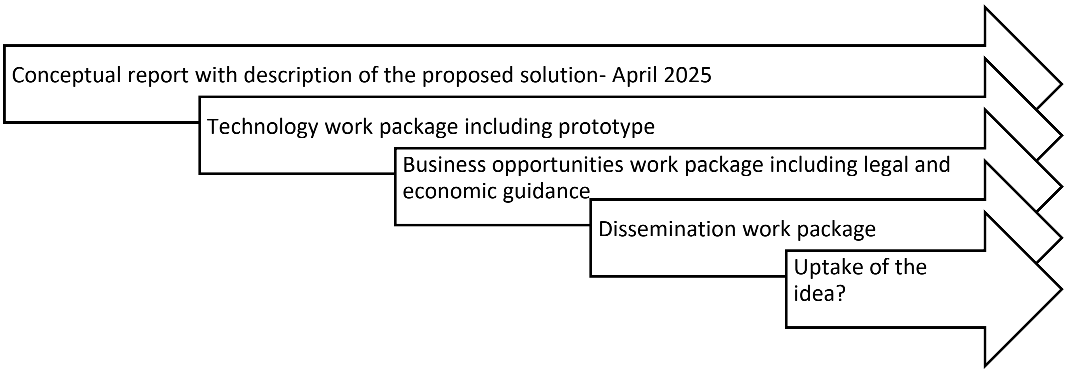

Figure 7 A simplified description of the envisaged full project activities (author's conceptualisation)

As described in Figure 6 above, the full project intends to deliver a “package solution” for farmers, including a prototype, guidance material addressing financial, legal and technical aspects, and a communication package.

The intention is to design a business concept around the project “Robusta Gården”, that could become both an advisory service product and/or a physical product (the actual microgrids).

To achieve the goal of putting decentralised microgrids on the market, the technical, legal and financial viability considerations of the project are essential and will contribute to embedding the “legitimacy” and “trustworthiness” of the project (Suchman 1995). It will be important to (i) have a prototype to show, (ii) clear the potential legal challenges linked to applicable energy laws and regulations, and (iii) produce a technology not too costly. Probably the word “affordable” may not be appropriate but it should certainly be within the resource capacities of most interested farmers. This is an aspect that the inception report has in mind: for which types of farmers the microgrids would make the most sense and benefit? Reaching out to farmers, and the organisation of information exchanges for and between farmers is an important part of the project and can be a significant factor influencing the strategic decision of farmers to take up or not decentralised microgrids. A study by Hansson and Ferguson (2011:118) on dairy farming showed the key role of network and social structure in appreciating farmers’ business choices.

It will also be key for the core project team to target and forge alliances with a wide range of actors, both private and public, such as municipality bodies and already existing energy companies to change the practices of the market. As mentioned in Section 5.2 above, it is understood that so far discussions with the local municipality and the energy company owning the grid have yielded no fruitful result. But first, they need to see what is in the project for them. What could be their benefits? (Kanter 1994). Once there is a viable prototype and concrete proposal, it is hoped that the project will have the necessary legitimacy, power and urgency (Mitchell *et al.* 1997) to influence these key stakeholders who have a voice in the decision-making process and could positively influence the institutional environment and help to reframe energy systems.

6. Discussion and Implications

This chapter discusses the findings presented in Chapter 5 and connects them to the theoretical framework introduced in Chapter 2. Linking the results and the conceptual and empirical theories, it also suggests a different "reading grid" of the innovation systems in Sweden.

The discussions held with the different stakeholders confirm the changing context of agriculture already well established from a variety of studies, and the need for a different mindset in advisory services and in particular funding organisations tasked to spearhead innovation and business development (Hebinck *et al*. 2018; Pigford *et al*. 2018; Klerkx & Begemann 2020). The "Robusta Gården" project is more an energy project than a typical agriculture proposal. The project illustrates well the need for innovation systems, whether agricultural or otherwise, to take a multifunctional, multidisciplinary approach to address complex problems such as energy and food security.

This means for advisory services to get out of their comfort zone and partner with unusual stakeholders, and for funding organisations to adopt a broader vision to include the farming sector within the scope of their funding capacity.

Funding organisations also need to think of expanding their goals, where economically and technically oriented objectives can co-exist with more value-oriented ones (Kojonsaari & Palm 2021; Nooteboom 2006). Since they may not all share the same core logic (Glasbergen 2010:4), collaboration may not be self-evident and may require a convergence of the stakeholders' "frames" (Gray 2004; Saville & Adams 2020). Hence, the "Robusta Gården" project shows that the main bottlenecks appear to do mostly with the way innovation is envisioned. The project illustrates that innovation needs to be understood broadly in the context of agriculture systems adapting to global scale phenomena (Kilelu *et al*. 2011).

The project is also constructed "bottom-up" where the farmer generates the idea. The project hasn't been initiated by a research body or advisory service already tapping into well-established funding lines, and with access to broader scientific knowledge of similar projects and networks. As explained by Glasbergen (2010:11), for partnerships to become successful, they must show environmental and business benefits and have the potential to create a model for others, whether businesses or governmental entities. Partnerships need therefore at one point to involve large businesses, market leaders or other types of organisations with significant leverage to change the political order, i.e. the practices of the current market environment. As Mitchell *et al*. (1997) already indicated the key attributes of not only legitimacy but also power and urgency can influence by extension a market or system.

In the particular case of the innovation system in Sweden, it would appear that the most profound challenge is to change the mindset and that directives at the top level trickle down to break the apparent silos unintentionally created between the different organisations and to increase connectivity. There is a role for government policy to help raise awareness, facilitate investment through procurement policies for example, give legitimacy to the new technology and enable the diffusion of the new technology (Carlsson & Jacobsson 1997).

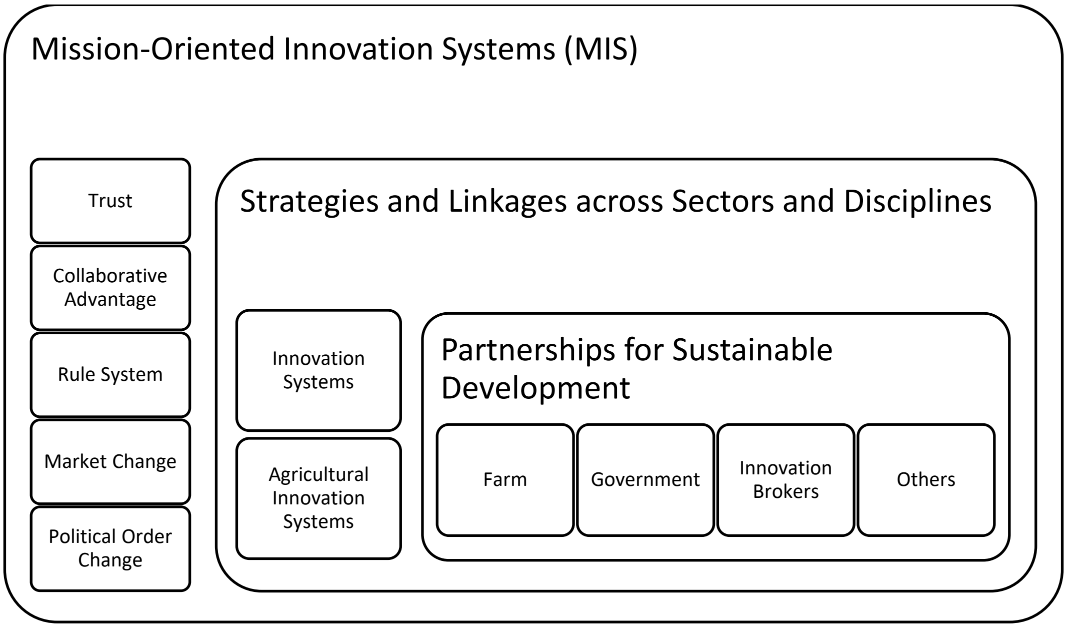

Figure 8 Partnerships for Sustainable Development in agriculture are an integral part of Mission-Oriented Innovation Systems, MAIS (author's conceptualisation)

Partnerships for Sustainable Development such as the case of "Robusta Gården" do not belong exclusively to a specific Agricultural Innovation System as illustrated in Figure 7 above, but to a broader Mission-Oriented Innovation System driven by the dynamics of building trust, and collaborative advantage, constituting a rule system, creating market change and ultimately changing the political power. Strategies and linkages across sectors and disciplines must therefore take place to break down barriers and allow a systemic approach.

The different theories of innovation processes towards sustainability, irrespective of their disciplinary approaches, all complement each other. From

Mission-Oriented Innovation System (Hekkert *et al*. 2020; Klerkx & Begemann 2020) to foresight processes (Hebinck *et al*. 2018), Innovation Ecosystems Approach (Pigford *et al*. 2018), etc. they all highlight the need for changes, a holistic approach, the engagement with different actors, public and private, as well as the need for good governance. As Börzel and Risse (2005:2) describe, albeit in a global context, Public-Private Partnerships increase the problem-solving capacity and the democratic accountability of governance.

The idea of Partnerships for Sustainable Development developed by Glasbergen echoes or complements the notion of Cooperative Management Regimes put forward by Meadowcroft (2007:2) which describes partnerships involving "organisations with their roots in different domains of societal life coming together around practical problems linked to the promotion of sustainable development". The "Robusta Gården" case study exemplifies these models whereby the partners:

- Come together around an issue (energy resilience),
- Engage with real issues (crises),
- Implement solutions (microgrids),
- Can draw lessons from experience, and
- Have the *potential* to institutionalise a new sense of collective responsibility for sustainability issues (Meadowcroft 2007; Glasbergen 2010).

It remains to be seen whether the "Robusta Gården" will ultimately succeed in solving the collective problem of energy resilience for farmers and rural communities. Innovation processes are not one-dimensional. As set forth by Leeuwis and Aarts (2011:2):

> "innovations do not just consist of new technical devices but also of new social and organizational arrangements, such as new rules, perceptions, agreements, identities and social relationships".

Firstly, if any further money is granted to start constructing the prototype and implementing other work packages, detailed deliverables will most likely be strictly defined. This contractual framework may limit the ambition of the initial project. It is understood that the Swedish Board of Agriculture might organise a specific, formal call for tenders and procurement contracts, or possibly organise another broader call for proposals with funding opportunities after the conceptual report is delivered in 2025, with the intent of engaging with more farmers in different production systems.

Secondly, the outcome might not necessarily lead to a transformative change of collective responsibility for sustainable issues depending on the agenda-setting of the different stakeholders. It may advance the partners' immediate objectives but further work may be needed to keep the process of change going. As the project evolves on the Ladder, critical issues will be encountered to forge strategic alliances with other key stakeholders, private and public, and get their support. Such issues will encompass *inter alia* goal compatibility, synergy among the partners, and the value and contributions that each partner brings to the project (Vyas *et al.* 1995).

This type of more advanced interaction and negotiation between the different stakeholders may therefore necessitate communication strategies in the sphere of network building, social learning and conflict management (Leeuwis & Aarts 2011). Carlsson and Jacobsson (1997:312) have also stressed that policymakers to support technological innovation should concern themselves with "high connectivity (…) based on the development of trust and a collective identity". This highlights again the importance of the process of network creation and collaboration that can lead to change.

7. Conclusions

This final Chapter suggests an answer to the research questions enumerated in Chapter 1, proposes key recommendations and outlines potential questions that could affect policies, theories and practices.

The objective of this research was to shed some light through an exploratory case study on the development of partnerships between different organisations and institutions in the Swedish Agricultural Innovation System. The research aimed to explore the enabling collaborative framework that supports farms in Sweden to be innovative in taking up self-sufficient fossil-free microgrids.

The following research questions were put forward:

(i) Is the existing innovation collaborative system adequate to reach the goal of energy resilience for farms and rural areas?

(ii) What needs to be changed or even transformed in the innovation system?

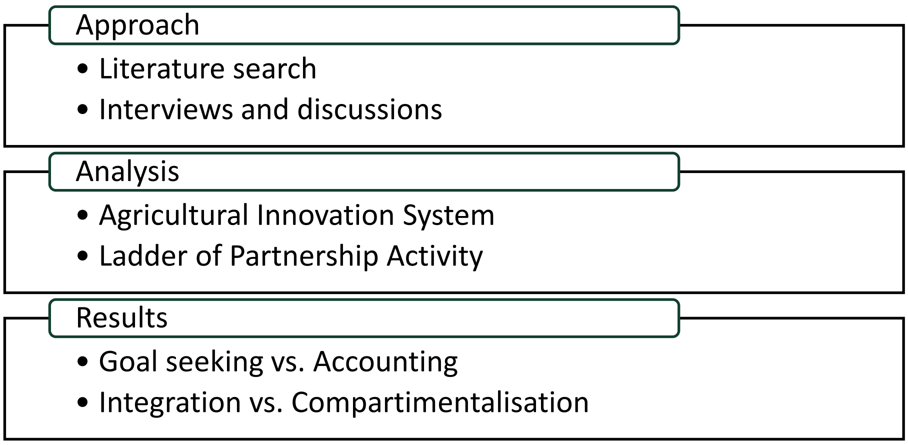

Figure 9 Graphical abstract of the research study (author's conceptualisation)

We can conclude that the current innovation collaborative partnership system presents opportunities for improvement. Figure 8 above gives an illustrative summary of the research study. While some funding organisations take a broader perspective on what projects they may be able to resource, others require stricter tangible criteria before committing to funding. Yet, the two types of funding organisations seem complementary and could strengthen each other through more collaboration. Similarly, some research centres seem to work to some extent in silos, whereas others show a more systemic approach, but this apparent dichotomy could pave the way to complementaries and different configurations of advice.

This project research also suggests that Agricultural Innovation Systems in Sweden should be considered an integral part of the broader innovation system which should be driven by a Mission-Oriented approach. Any improvement in that direction would consist of a non-technological innovation in its own right, towards more sustainable farming systems through novel collaborative configurations (Klerkx *et al.* 2010).

On a broader perspective, we also hope to have provided a viewpoint for integrating and reconciling the different conceptual and empirical models of innovation process and governance for sustainable development. We used the theory of Glasbergen (2010) on collaboration in innovation journeys concerned with sustainability issues as an overarching initial theoretical frame to facilitate the exploration of the phenomenon under study. Our findings suggest that this model is encompassing and provides plenty of scope for integrating complementary notions, concepts and practical examples.

7.1 Policy Recommendations

The exploratory case study has underlined the importance of holistic system-based approaches and coherent policies as prerequisites to sustainable and resilient energy and infrastructure projects in the agri-food sector.

Based on the conclusions of this study, we suggest the following general and interlinked recommendations for policymakers in their agenda-setting:

- Identify the silos, and enable connectivity and collaboration in the national innovation system, while still legally protecting emerging innovations. For example, enable more collaboration between the Swedish Board of Agriculture and the Swedish Energy Agency.
- Help to build trust relationships amongst the different stakeholders to enable them to create new business models and deliver environmental, social and economic benefits to local communities.
- Facilitate better linkages between research and advice in the broader agri-food system.
- Enhance the capacity building of intermediary services through partnerships or facilitation of exchange.

- Communicate regularly with stakeholders and create a better interconnection between science, policy (including laws and regulations fit for purpose) and society.
- React quickly and positively to farmers' needs and demands through new types of collaborative projects.

7.2 Methodological Reflection and Limitations

The researcher is not a neutral observer; to the contrary, the research might reflect personal biases based on certain assumptions and embedded paradigms. The design of the research, the choice of methods and theories, and the analysis and interpretation of data may be influenced by personal factors such as prior knowledge, personal values and life experience (Bell *et al*. 2022: 38-42). In this particular study, the fact that the author knows personally the unit of analysis (the dairy farm), has a pre-understanding of the setting and has an interest in the social fabric of rural communities, may have influenced what and how they saw the problem.

This specific case study also raises questions as to the possible generalisation of the findings and external validity of the research. We acknowledge these challenges and view our project research as exploratory.

A different lens could have been used to reflect upon the problem. The general theoretical model proposed by Glasbergen (2010) was used to explore the phenomenon, but other analytical frameworks could also have been used and highlighted different policy areas, challenges and opportunities. A different method to reflect and learn about the agricultural innovation process once matured, could be used, such as innovation histories (Douthwaite & Ashby 2005; Spielman *et al*. 2009). Since the "Robusta Gården" project has just started, the study focused more on the dynamics between actors, institutions, ideas and solutions, rather than actual transformation pathways, and future visions and scenarios following an innovative breakthrough.

7.3 Suggestions for Future Research

The selected research unit just started its partnership arrangement and it would be useful to follow the "Robusta Gården" project to see its evolution from start to finish on the "Ladder of Partnership Activity". It would also further the understanding of how the existing system encourages the innovation capacity of farmers to become a reality.

In this project, each activity in the Ladder of Partnership as a whole has been considered, with a more concrete focus on the two first steps, building trust and collaborative advantage. It would be interesting to further analyse the next steps of the Ladder and address how and why the ‘Robusta Gården” project partnership has progressed. Depending on the outcome, a particular relevant activity of the Ladder could even be delved into in its own right. For example, the research field of trust building is very rich and the project partnership could be exclusively analysed from that particular lens.

The problem could also be further explored from the complementary lens of politics, law and regulation, or a broader societal and technological perspective. It could be relevant to look further into institutional trust and the dynamic interplay between the agenda-setting of the different governmental institutions, the research and intermediary organisations. The completed case study could serve to analyse good governance mechanisms (for instance, looking into food and energy policy coherence across all levels of governance), and to which extent broader societal discussions on rural energy communities have been fostered, for example.

The field of innovation processes and systems and their role in socio-economic development is vast and perpetually in movement. The “Robusta Gården” project could also provide the starting point to clarify the role of communication in innovation processes thinking, beyond network-level interventions. More studies could be of interest to better understand what communication strategies can influence a broader and meaningful system change in agriculture innovation systems.

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Popular Science Summary

Farmers are asked to do ever more for the environment and society, yet they face many economic challenges. Climate change, natural disasters, pandemics and wars have recently put unprecedented stress on our food and energy supply chains. These crises have generated power outages or expensive, fluctuating energy costs. Farmers are seeking innovative, sustainable alternative energy sources to ensure their energy independence and income. Dairy farmers, for example, have turned to renewable biomass energy to reduce energy use. However, their biogas plants are still connected to the main electricity grid and this setup isn't entirely satisfactory. For this reason, decentralised microgrids using biomass from manure could allow farmers not only to reduce costs and become self-sufficient but also to continue producing food and saving much-needed energy. The farmer would become independent from the central electricity grid and resilient to external shocks. A long-term vision is also to avail the surrounding community or village of this renewable source of energy.

However common sense it may look like, securing support and funding to explore what type of decentralised microgrids could work in a Swedish context, isn't simple. Finding the right partners requires a great deal of effort and determination, but convincing the competent authorities and stakeholders that such innovation could have environmental, social and business benefits, as well as the potential to create a model that other farms could follow or that the government could roll out nationwide across sectors, can become an uphill battle.

Based on a specific case study, the purpose of this project is therefore to look into innovation partnerships aiming at developing a model of decentralised microgrids that could work on farms in Sweden. More specifically, the objective is to see whether these collaborations are adequate to reach the goal of energy resilience for farms and rural areas and to focus attention on what needs to be changed or even transformed in the innovation system.

Partnerships in innovation in the agriculture sector in Sweden often involve the dynamics of three types of actors: farmers, government agencies and innovation brokers such as universities, research centres or intermediary services who can also include funding organisations.

The results show that while there is goodwill from competent authorities, research and funding organisations to support innovative ideas, they may have diverging expectations and goals. While some authorities or organisations are keen to support an idea or project at its inception phase, others want to have demonstrated, measurable benefits before investing in the project. This is a Catch-22 situation for innovators, especially since pro-activity rather than reactivity is needed to achieve sustainable development goals. Further, many challenges in the agriculture and food value chain need a multidimensional and integrated approach. The idea of decentralised microgrids cuts across sectors and disciplines. Too many governmental agencies, funding organisations and research centres still administer and work in silos. While they may have the enabling support to advance on energy resilience matters, they consider they don't necessarily have the mandate to concern themselves with the agriculture sector and help to develop energy resilience for farmers and rural communities.

There is therefore a great opportunity for governmental institutions, funding organisations and research centres to improve their foresight strategies and bridge the gaps between policy and practical innovation. Another critical point is that better inclusion and participation of farmers and local communities in environmental governance in general, and not just for agronomic issues, are crucial to sustainable transformation pathways.

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Appendix 1 Interview Questions

This is a sample of some of the interview questions for the experts. Each interview was unique and different aspects were introduced depending on the expert and previous data gathered.

- How did you decide to support the project? How did you come about this project?
- Why did you care about this project?
- What is the timeline of the project?
- What has been done so far? At which stage of the project are you now?
- What are the next steps?
- With whom did you get in touch?
- How do you find the collaboration with (…)?
- Do you think there is enough support from (…)?
- Are you following some emerging energy topics?

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