Collaboration and Trust: The HHK Testbed Approach to Building Sustainable Systems

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Abstract. This paper presents an ethnographic action research study where we have interpreted data collected in and around a cluster organisation focused on innovation and change-making. This paper examines how organisations within a triple helix of innovation can unite and work to establish a common platform in the form of a test bed, where the challenge of a green transformation can be addressed from all participants' perspectives. Test beds represent an experimental and co-creative approach to the construction of an innovation policy that aims to test, demonstrate and promote new socio-technical systems and associated modes of governance in a model environment under real-world conditions. The examined cluster includes industry, local- and regional government, academia and a state-owned research institute. Trust is crucial to building collaboration within the triple helix model of innovation and trust takes time to develop and to spread within the triple helix. Trust enables communal investments, such as the construction of technology demonstrators, based on shared research. These physical artefacts can be seen as evidence of the value of collaboration, which in turn further strengthens collaboration efforts.

Keywords: Innovation governance · Sustainable Transition · Testbed · Collaboration · HHK

1 Introduction

The transition to the digital age is also beginning to transform fluid power systems. According to Linjama [1], digital fluid power can be defined as a hydraulic and pneumatic system with individually evaluated components that actively controls the performance of the system. In other words, the design of digital fluid power systems does more than just use the digital control of analog systems [2, 3]. While there are some challenges in component development, control modelling, simulation, and dynamic effect processing, technological development of some basic components such as digital pumps, digital cylinders, and transformers has already been achieved [4].

At the same time, companies working with fluid power technologies have faced the symbiosis between digitalization and electrification [5]. Electrification can be defined as

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the process of replacing technologies that use fossil fuels (coal, oil, natural gas, etc.) with systems that operate on electricity. Another way to explain electrification is to think of it as a source to decarbonize final energy consumption in all sectors of the economic system [6]. As a result, the benefits of electrification can be assessed by reducing greenhouse gas emissions, ensuring an affordable and safe energy supply, improving energy efficiency, improving urban air quality, and recruiting new, high-quality jobs through the only well-planned transition. More than that, achieving carbon neutrality may decrease the risk of climate change.

It seems clear that on the technology level, research on digital fluid power system design has advanced well. However, what is not clear is how innovation managers, product engineers, policy makers, and the civil society have prepared themselves to deal with the transition to electrification and digitalization. Having this challenge in mind, the aim of this paper is to investigate how to encourage advancement inside the setting of a cluster of small and medium enterprises? How to foster an organisational ability to use both the capacity to simultaneously operate in markets where effectiveness, control, and incremental change are prized and to likewise contend in innovations and new markets where adaptability, autonomy, and experimentation are required [6].

The aim of this paper is to examine how organisations within a triple helix could unite and work to establish a common platform where the challenge of a green transformation can be addressed from all participants' perspectives.

To answer this question, we used the action research approach to present the case of Hudiksvall Hydraulics Cluster (HHK). HHK is a group of companies, all situated in and around the town of Hudiksvall, Central Sweden. The companies in HHK are relevant to the question because they are transitioning from petroleum-based technologies to low-carbon technologies, such as electrification. Our assumption was that trust and collaboration are core values in this change process.

The remainder of this paper was organised as follows. In Sect. 2, we briefly introduced the concept of ambidexterity and the main trends on testbeds. Section 3 presented the methodology used to answer the research problem. In Sect. 4 we proposed an analytical framework that can help innovation managers enable collaboration. In Sect. 5 we present the concluding remarks.

2 An Overview of Testbeds for a Society in Transition

The principal versatile test confronting firms was the need to both endeavour existing resources and capacities (exploitation) and to accommodate adequate innovation (exploration) to abstain from being rendered superfluous by changes in business markets and technological change [7]. Considering the possibility that diverse structures are required for exploitation and exploration, the literature on the topic recommended that for long run survival, companies are expected to engage in both.

To become an ambidextrous organisation, it is recommended that this could be refined by setting up self-sufficient exploration and exploitation subunits that were basically isolated, each with its own arrangement of individuals, structure, and procedures focused on guarantee the utilisation of assets and skills simultaneously. But how to do so in a fast-changing world?

Testbed – and similar concepts such as "living labs" or "real world labs" – emerged as an approach to structuring and stimulating innovation by testing new sociotechnical configurations in situ and at a meso-scale [8, 9] These methodological approaches have been used to promote innovation in geographic regions and in emerging technological domains. They are an evidence-based response to face three major interconnected challenges: climate change, the growing deficit of decent work opportunities, and the need to drastically alter the energy matrix, reducing the consumption of fossil energies. Appropriate policy responses to these challenges will require drastic transformations of technology and society.

In this sense, test beds represent an experimental and co-creative approach to the construction of an innovation policy that aims to test, demonstrate and promote new socio-technical systems and associated modes of governance in a model environment under real-world conditions.

As real and physical spaces, test beds can be used for open innovation, facilitating co-creation with the different actors interested in its result. Living Laboratories are methodologically organised into two levels. While an overall structure provides stability and continuity, a second level below allows for spontaneity within projects [10]. Likewise, the structuring allows and determines the implementation of methods within a testbed [11].

3 Research Design

To answer the problem posed in the paper we have proposed to use the ethnographic research action method which allows the researcher to be an active participant in the process. Action research (AR) can be described as adaptive, pragmatic and solution driven. Action research pursues two outcomes: action (change) and research (understanding) [12]. Because it is participative, action research enables change and that often happens together with other change processes. Action research can also be regarded as a learning cycle that is relevant for advocating change. "The research is achieved by being responsive to the situation and by searching strenuously for disconfirming evidence. At the heart of AR is a cycle which alternates action and critical reflection. Action and research enhance each other" [12]. In addition, action research is the correct research methodology if it is a situation in which there is increasingly:

- Power sharing and the relative suspension of hierarchical ways of working, in a conscious move towards social and industrial democracy.
- Collaboration among members of the group as a 'critical community'.
- Self-reflection, self-evaluation and self-management by autonomous and responsible persons and groups [12].

3.1 Participants

We focus this study on a limited group of HHK-members and associated organisations. They have been chosen because of their role within the triple helix:

- Hiab, Huddig and HSP Gripen (industrial manufacturing members)
- Research Institutes Sweden AB (research institute)
- Linköping University (academia)
- Hudiksvall's kommun (municipal government)
- Region Gävleborg (regional government)

Hiab is a global company and part of the Cargotec group. They are a leading manufacturer of loader cranes worldwide and have approximately 3.500 employees. Hiab has a target to halve CO2-emissions from products and operations (2019 levels) by 2030. Electrification is considered one of the most important tools to reach the target.

Huddig is the only complete system manufacturer in HHK and they were among the first on the market to produce a full electric hybrid back-hoe loader, presented to the public in 2016. Huddig has 120 employees in total and Hudiksvall is the only site for manufacturing and R&D.

HSP Gripen is the smallest company in the sample. They produce large grapples for forestry and manufacture almost the entire product in-house.

Hudiksvall's kommun is the municipal government where HHK is active and it is a non-active member of HHK. The municipality is in 2022 managed through a coalition between social democrats and moderates.

Linköping University's (LiU) Fluid and Mechatronic department has had a standing collaboration with HHK since 2016. The university is one of Sweden's most important centres for applied industrial research with around 32.000 students. LiU has been a part of the HHK board of directors since 2018.

Region Gävleborg is the governing body in the region where Hudiksvall is situated. The regional government is responsible for creating a regional development strategy (RUS), a regional steering document that outlines the orientation of the region's future development. The strategy's five target areas are:

- Attractive and accessible locations
- Socially beneficial, circular and bio-based economy
- Competitive businesses and sustainable labour market
- High knowledge and innovation ability
- Equal and egalitarian society

3.2 Data Collection

Data was collected during studies, in-depth-interviews, technical-, strategic- and tactical workshops, board meetings, conferences and events. The researchers have been part and present in activities concerning HHK from the first pilot study initiated in 2012 and published in January 2013. Material has been collected in the form of commissioned studies, marketing materials, digital media, presentations, meeting notes, self-documentation, artefacts, audio, video and photography.

3.3 Data Analysis

Data has been organised and interpreted according to the ethnographic action research model. Interpretive research can be described as when the researcher is immersed in a

particular social setting and has deep knowledge of the people involved and an understanding of their worldview. Social knowledge is produced from all encounters, conversations and arguments that interpretive researchers have with the people they are studying [13].

The interpretation of the data requires an understanding of the context. The data analysed in this study was not captured or produced for a single purpose. A video can first have been used for documenting an event and later the same video could appear in marketing material or in a social media post. The researchers are not only retrieving and studying the data – they are also central to running day-to-day operations in HHK and central to establishing a testbed for transformation.

The data has continuously been reassessed with the emergence of a better understanding of the context, following the tradition of cultural analysis which can be described as "guessing at meanings, assessing the guesses, and drawing explanatory conclusions from the better guesses" [14].

HHK's purpose guides the organisation and informs all of its decisions and actions. The purpose is important to understand in order to analyse and draw conclusions from the data. A definition of purpose is proposed as "an aspirational reason for being which inspires and provides a call to action for an organisation and its partners and stakeholders and provides benefit to local and global society" [15]. Business is seen to consume trust rather than to generate trust. NGOs on the other hand enjoy a higher level of trust than commercial businesses. It is also suggested that companies should pursue a purpose beyond purely financial gains to increase trust [16, 17]. Since HHK can be defined as a non-profit organisation that operates independently of the government, but with members from local government, academia and business – a strong organisational purpose is considered paramount by the organisation to enable collaboration. HHK's purpose has been described as:

> *"To create conditions for a constant search of knowledge that can make us economically, socially, and environmentally sustainable."*

HHK aspires to create those conditions by providing a playground for professionals, where they can step outside their day-to-day obligations to realise their full potential in a safe space where failure is accepted.

4 The Experience of Transition in the Hudiksvall Hydraulics Cluster

In 2016 the cluster accelerated its operations when global industry groups moved production from Hudiksvall to low-cost countries. It became apparent that closer cooperation within local industry was necessary to strengthen competitiveness, to increase innovation and to make it easier to recruit talents. Direct competition between companies in HHK is almost non-existent.

Collaboration within HHK is solely built on trust. There are no formal documents that regulate interaction between the members and communication on the shop floor between the members is generally encouraged by managers. Relationships within Linköping

university and with officials in Region Gävleborg that work closely with HHK are also trust-based. This model has been highly successful and can be considered as part of the business culture in Hudiksvall.

Currently the most important project in HHK is to establish a national testbed for "electrification of complex machines and for green transformation" in Hudiksvall. The project, which is in the making, is designed around collaboration between industry, government and academia. The project title is "Testbed for transformation: Electrification of Complex Machines in Complex Environments". The project has entered the second of four phases. In the second stage the project is set to deliver A.) a deeper understanding of different needs within the triple helix, B.) increased cooperation within the triple helix around a testbed, C.) increased knowledge of factors that affect social sustainability considering electrification and D.) a working business model and financing plan for a testbed.

4.1 Experiences of Collaboration and Testbed Design

Cooperation between industry, academia and government has been described as the triple helix model of innovation. The triple helix model forms a prominent part of the Swedish innovation system where academia, industry and government cooperate to identify, research, and develop innovative technologies and services that meet the nation's needs [18]. To increase the potential for innovation and economic development the role of academia should be more prominent and there needs to be a "hybridization of elements from university, industry and government". This creates the potential to generate new ways to produce, transfer and apply knowledge [19].

The planned testbed is a nexus of HHK's electrification journey that started with new innovations from member companies. Huddig initiated the development of the Tigon electric hybrid back-hoe loader in 2012. In 2014 Hiab started developing the ePTO (electric power take-off) electrified loader crane-platform, in collaboration with Volvo Technology AB. These initiatives inspired the formation of the research project STEALTH (Sustainable Electrified Load Handling) in 2016 – a joint effort between HHK and Linköping University (LiU). LiU became an academic partner to HHK in the process and as a consequence holds a seat on the governing board.

4.2 STEALTH: Research as a Catalyst for Broader Collaboration

With academic research, knowledge-sharing increased within HHK and that led to improvements to existing products in HHK. This has happened primarily at Hiab and Huddig, which are at the forefront of electrification in HHK. When local industry so visibly focused on electrification, the Hudiksvall municipality could also draw on a strengthened local brand in this particular field. Battery cell manufacturer Northvolt courted several Swedish regions in 2020 as they planned for a new factory. The HHK brand was by now so strong in the field of electrification that it was used by two local governments in a bid to attract investment from Northvolt in two different regions.

4.3 SkwX: Bespoke Innovation Method to Drive Unity

The transition to electrification has also aided HHK in developing a proprietary innovation methodology (SkwX), specifically as a tool to boost innovation across organisational borders. SkwX as a workshop and method takes many characteristics from traditional design thinking tools. What makes a difference is that SkwX is a brand and a method for innovation that stems from within HHK, with the intent to increase innovation across company borders. Because it is a proprietary method, created in-house, and reliant on trust between stakeholders; it lowers the threshold for legacy industries within HHK to work with innovation in unorthodox ways.

Simplified, it can be said that product development within HHK and the fluid power-industry in general has traditionally put a premium on continuous power increases for components and systems. In electrified systems, where instead a premium is put on energy efficiency, this thinking is outdated. By working on innovation across company borders, manufacturers of components and subsystems that form part of a complete system (e.g., a truck with a hydraulically controlled loader crane), can better understand how value for the end user is created with electrified products.

4.4 Rapid Commercialisation of Innovations

The participation of academia in SkwX-workshops has been a key success factor for the STEALTH-project and for the commercialisation of new engineering solutions. The different perspectives of engineering, business and research become visible to everyone, and the experience brings people together. As a result, the time for results from academic research to reach the market has proved to be short, ca. 3–6 months. The Hiab e-roller crane, launched in 2021, is a result of this – as is new functionality being added to coming generations of the Huddig Tigon. During its development, Huddig gained explicit practical experience in building battery packs due to the Tigon machine development. With the help of Huddig, Hiab could rapidly create new experimental battery packs. In turn, Hiab assisted Huddig with design calculations.

4.5 Education and Transition

Education of specialists and academic research is a long-term investment, and it is vital to deal with- and to understand the multitude of new aspects the transformational challenge brings. Industry has an urgent need for specialists, best illustrated in HHK by Hiab which has committed to reaching the 1.5 °C-target by 2030 [20]. Digitization and electrification in combination creates an area that will likely create a need for more specialists within industry. New technologies in combination can create new opportunities only to be explored, understood, and embraced with the creation of new professional roles.

4.6 A Culture of Trust as a Driver for Transformation

The strategic intent is that by investing in a testbed for transformation built on the trust-model that has shaped HHK and that channels the needs of industry, government and academia; would reduce barriers between stakeholders, increase shared knowledge

and reduce risk, which is inherent in a transformation. To achieve the same level of trust between all three stakeholders would be hugely beneficial, yet difficult to achieve. The challenge can however be alleviated if stakeholders are included gradually into the existing culture of trust.

The traditional boundaries of responsibility between academia, government and industry might not be applicable, or even desirable, in a testbed for transformation. These institutions can all contribute to generating innovations, but for that to happen a "consensus space" is needed "where the actors in the three spheres can come together in the spirit of mutual understanding and trust". Systemic innovations can happen in the consensus space via technology transfer, collaboration and conflict moderation, leadership, and networking [21]. The preliminary design of the testbed is meant to create such a consensus space.

The triple helix can also produce 'hybrid organisations', which spring up at the intersection between sectors, such as public- and private, civil- and public, private- and academic. Hybrids can be established as platforms for sharing resources and for creative purposes. They can also contribute with technical and social innovations that can handle complex and "wicked" problems [22].

The green transformation can arguably be defined as a "wicked" problem. Wicked problems cannot be definitively formulated, they can all be regarded as symptoms of other problems and there is no way to ultimately test a solution after it has been implemented, as any solution will generate waves of consequences over an unforeseeable future [23]. These complex and fluid problems have to be handled with flexibility, reflexivity, and learnings [24].

5 Concluding Remarks

A testbed for electrification can create knowledge for individual organisations (e.g. testing of technical systems and components). It can also create shared value for all stakeholders in a triple helix – as a result of collaboration and increased levels of trust. Each stakeholder holds a piece of the green transformation-puzzle and with perspective-taking and communication, the collective can use the testbed to see the whole picture.

Industry, public office and academia are highly specialised in their respective tasks. When all sectors in the triple helix work separated from each other, insights will not be shared and the transition to a CO2-neutral society moves at a slower pace. Policy decisions can for instance hinder the overarching goal of achieving a climate neutral society. An example of such a mismatch in Sweden is that public organisations are not obliged to buy services (e.g., road maintenance, construction, logistics) delivered using machines with a low carbon footprint. It results in increased cost for machine manufacturers and weak markets for sustainable machines.

A testbed with the purpose of being a shared platform for understanding the impact of action and inaction across the triple helix can help stakeholders share perspectives so decisions can be aligned, thus increasing efficiency and speeding up the green transition. A testbed with this purpose can help the organisations that are on the "inside" to make better decisions and it can aid a broader group of stakeholders on the "outside" by showing what works and what doesn't work. The testbed would act as a storefront for the broader society where methods, experiences and solutions can be shared.

Experience shows that the process of transformation and systemic change is challenging to understand. To create a broad understanding both within and without the testbed, we believe that it is vital for it to enable the creation of prototypes and demonstrators, involving all sectors of the triple helix. Seeing is believing. With these prototypes, the impact of decisions can be made visible across the triple helix and the shared perspectives will help stakeholders enable new solutions – be it in the fields of technology, policy, society or financing.

In this scenario the testbed is a meeting place, where proof of concepts are created and vetted within a triple helix to better understand the implications of strategic decisions to enable transformation. Successful proof of concepts that can speed up the transition to a carbon neutral society can be further developed and researched outside of the testbed to reach higher technology readiness levels. We suggest that to enable the recruitment of a broad stakeholder group for a testbed based on the triple helix-model further work could study how to uncover and visualise potential values of a testbed based on the triple helix. Furthermore, it would be beneficial to further research how to strengthen and increase trust between stakeholders in a triple helix.

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