CHALMERS
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Exploring Networked Business Model for Electrifying Swedish Construction Industry

From An Industrial Network Perspective

Master's thesis in Technology Management and Economics

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SUMMARY
With the goal of realizing net zero emission by 2045, the electrification in Swedish construction industry is gaining more attention. The exploration in this area just started but already presented challenges from two aspects: lack of collaborative network and lack of motivation. The former challenge occurs mainly because of the feature of construction industry, which accounts for the slow adoption of innovation in general. The latter one is triggered by new demands due to the electrification. In order to address these challenges and facilitate electrification in Swedish construction industry, networked business model is explored following the process of identifying current and potential business network, organizing challenges and opportunities, and finally proposing three business models, covering integrated pilot project solution, integrated electric equipment solution and integrated power supply solution.

Keywords: Electrification in Swedish Construction Industry, Industrial Network Perspective, Networked Business Model, Integrated Solution.

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It can show the high level of enthusiasm about the topic in the industry, which is another thing we really appreciate for. So big thanks are also sent to all the companies and interviewees involved in this study, with whom we had many interesting conversations and discussion. From different perspectives, they helped us gain a more comprehensive understanding of the issues. Moreover, their practical efforts in promoting the electrification play an important role in inspiring us. It provided us hope and confidence while exploring and doing the research.

Last but not the least, we also want to thank our families and friends, who are always there and stand beside us. They always try their best to support us in their own way wherever they are. Some of them are mentioned here specially: Xia, Simin, Natasha, Nastya, Yuge, Yiwen.

Ru Chen & Shuai Li , Gothenburg, June, 2023

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Introduction

This part clarifies the research background, aims, limitations, and specific questions.

1.1 Background

The United Nations Environment Programme (UNEP) reports that the buildings and construction industry is falling short of its decarbonization goals by 2050 (UNEP, 2022). Fortunately, there is still a tremendous opportunity for the industry to make a positive impact, given that 70% of the world's urban infrastructure has yet to be built to meet the needs of a rapidly growing population. This is aligned with Swedish construction sector's agreement on a joint roadmap for fossil free competitiveness, with the goal of reaching net zero emissions by 2045 (Federation, 2018). In this company-led initiative, a full-fledged green transition and new business models are expected throughout the entire value chain of construction sector.

In order to achieve fossil free construction sites and logistics, the electrification of construction equipment and vehicles has been on the agenda and strengthened by the emerging market. The transition is being led by the application of small compact machines, especially in urban development requiring more demands on controlling emissions and noise (Wyatt, 2023). Nordic countries are actively embracing this trend and committing themselves to its implementation. In Oslo, all municipal construction sites will be required to use electric or other zero-emission technology by 2025 (C40 Cities Climate Leadership Group, 2020). While there is no explicit requirement of adopting electric vehicles and machines in Gothenburg, several pilot projects are commenced like Electric worksite and Electra, involving variety of actors across the construction supply chains. Charging solutions also stand out as a potential business area in terms of the diverse technologies including charging infrastructure, mobile battery containers, and dynamic charging roads.

Although the trend towards electrification in the construction sector is promising, the widespread electrification is within its challenges in this conservative and fragmented industry. The skepticism towards the reliability of electric equipment and the varying viewpoints of innovation experts, already shows the significant resistance

in adopting new technologies (Jonathan & Mohammed, 2022). For the innovation to occur in the construction industry, it is crucial to negotiate with multiple actors involved across projects (Winch, 1998) and form a long term business networks (Dubois & Gadde, 2002). The creation of new and viable business model is in the need to capture the value of electrification, and present convincing solutions to different actors combining the feature of construction sector.

However, several studies indicate that there are no established theories on business models in the construction context, with managers often having a partial and subjective understanding of the concept (Pekuri et al., 2013c; Berg et al., 2021a; Das et al., 2020). Consequently the study of business model is constrained to bring up the operation logic instead of proposing a managerial tool for the construction sector (Pekuri et al., 2013a). This has limited the exploration of the potential for added value in the industry, leading to a focus on bidding wars rather than differentiation in project delivery (Pekuri et al., 2013c). Notably, most of research tend to discuss business model in construction sector from a single firm's perspective, leading to a unsolvable situation (Pekuri et al., 2013a). Instead of copying business model theories from product-based manufacturing, three levels business models of project, project network and business network are identified for project-based industry, suggesting its inclination to span organizational levels (Wikström et al., 2010). Hence under the trend of electrification, the investigation of networked business models and their impact on construction industry not only can help promote the transition, but also reflect upon the long-existing challenges like price competition and slow uptake of innovation.

1.2 Aim and Limitations

It aims to help promote the electrification in Swedish construction industry by exploring potential business models. This study starts from analyzing the business network of Swedish construction sector from the perspective of Industrial Network Analysis (INA). It serves as the foundation for identifying specific challenges and possibilities in electrifying Swedish construction sector. Based on which the potential business opportunities and networked business models are proposed. Notably, the proposed networked business model here is limited to a concept level and need further investigation on the feasibility.

1.3 Research Questions

The results of this study are expected to answer the following questions combining different perspectives:

(1) What are the feature of business network in Swedish construction sector and what is the impact that electrification could bring on the network?

(2) What are challenges and opportunities in electrifying Swedish construction sector?

(3) What forms of networked business models for promoting electrification in the Swedish construction sector can be identified?

2

Frame of reference

This chapter synthesizes relavant theories into three section: industrial network perspective, construction industry and innovation, as well as networked business model. This part consists of several iterations as data collection and analysis move forward.

2.1 Industrial Network Perspective

2.1.1 A Model of Industrial Network

The basic definition of industrial network is that actors, resources and activities (ARA model) are interlinked with each other in a overall structure (Håkansson & Johanson, 1992). The circulation of the three elements shown in Figure 2.1 can be illustrated with a transaction context.

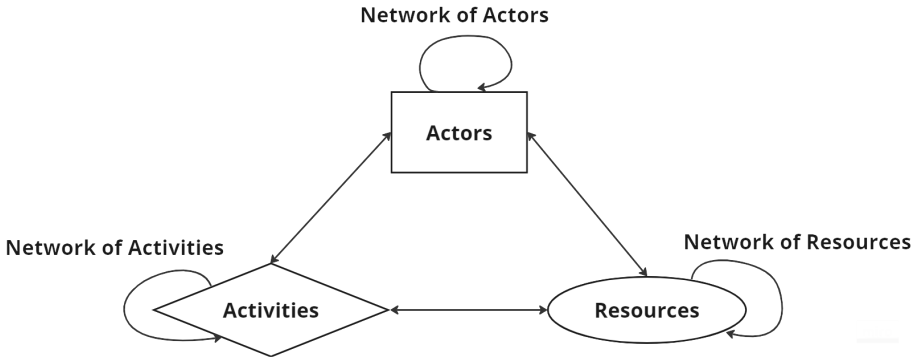

Figure 2.1: Actor-Resource-Activity Model, adapted from the study (Håkansson & Johanson, 1992) .

Actor: As presented in Figure 2.2, business actors consist of individuals, individual companies and groups of organisations, having control over a certain resources and activities. Different actors can utilize their resources in various ways, leading to diverse activities falling into two main categories: transfer activities and transformation activities (Håkansson & Johanson, 1992). Resources are changed in transformation activities whereas transfer activities are merely to give the direct control over resource to other actors (ibid.). Here the transaction relationship is

defined as the one formed by transferring resources and activities across different actors. Actors can also act and establish business relationship with each other (Koporcic, 2017), in turn, actors are considered extremely powerful with the support of business network (ibid.). The establishment of business relationship or network is an essential achievement through the mobilisation of resources and activities, providing an mutual development and learning environment for each actor involved in the network (Snehota & Håkansson, 1995). The importance of individual actors is even considered proportional to the significance of business network which they are part of (Håkansson & Ford, 2002).

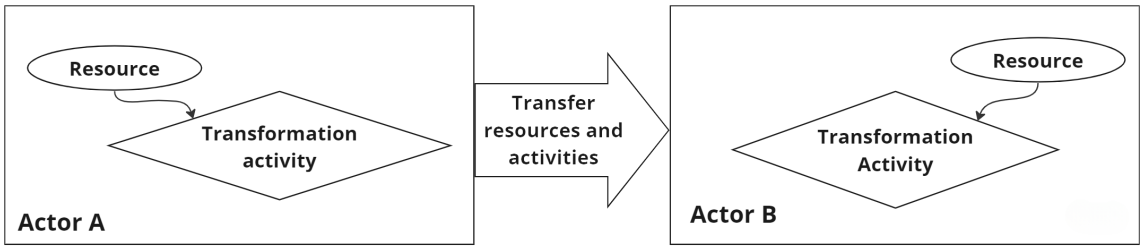

Figure 2.2: Transaction Chain, adapted from the study (Håkansson & Johanson, 1992).

Resource: By the 4R (four resources) model, resources can be grouped into two physical and two organizational types (Håkansson & Johanson, 2016): 1. The products of any particular organisation; 2. The facilities or equipment used to produce and deliver these products; 3. Organisational units that represent the knowledge, work practices, and ability of people involved in a company or organization to work with other organizations; 4. Organisational relationships between any other organisations that can be used to create more efficient resource combinations or activity links over time. Notably, the fourth resource or business network formed by actors are also defined as one kind of resource since it can bridge other resources (Snehota & Håkansson, 1995).

Activity: The mobilisation of resources such as flows of goods and information spans multiple companies forming a chain of activities or supply chains. The linked activities create interdependence between companies and their counterparts, which can be viewed as valuable opportunities to explore with (Gadde et al., 2003). In order to enhance productivity and performance, one firm is suggested to actively connect its own activities with others, instead of only maintaining core business activities in house and adopting a transaction relationship (ibid.). Notably, activities should be combined purposefully to facilitate the influence of the network on each other.

2.1.2 Two Types of Exchange Relationship

Based on different combination of activities and resources, a variety of business relationships can occur between organisations falling into two distinct groups: economic exchange relationship and non-economic exchange relationship (Håkansson & Johanson, 1992). Economic exchange relationship is driven by market forces, such as supply and demand, competition, and pricing. Cultural and social factors,

along with political and legal institutions, can also exert influence on it(ibid.). As a prominent economic exchange relationship, buyer–seller relationship is formed by exchanging four elements: product or services, money, information and social network (Metcalf et al., 1992). The exchange activities evolve over time as routines, developing clear roles and responsibilities of involved business actors (ibid.). Three foundation elements of the relationship are identified as: investments in tangible and intangible resources, contract based trust and involvement (Handfield, 2019). The establishment of a stable buyer-seller relationship can benefit firms secure resources, fulfill orders, and generate profits (Bygballe et al., 2014).

As the origin of industrial network, economic exchange relationships has been dominated in both practice and research. It is argued that potential economic exchange relationship cannot afford to be ignored. In particular, non economic relationship always exist before a economic exchange relationship is formed between organisation (Axelsson & Easton, 2016). Non-economic exchange relationships can help to build trust, social capital, and long-term partnerships that go beyond transaction relationship. Examples of non-economic exchange relationships in industrial networks can include collaborations between firms to jointly develop new products, knowledge sharing between firms to improve process efficiencies or quality, and partnerships between firms and academic institutions to conduct research and development. These types of relationships are often characterized by a high degree of trust, mutual investment, and emotional connection, and can lead to a range of benefits, including increased innovation, improved supply chain performance, and enhanced reputation (ibid.). In order to capture the potential of non-economic exchange relationship, the use of atmosphere analysis is developed by characterising relationships using four dimensions: power-dependence, co-relation, distance and mutual expectation (Axelsson & Easton, 2016). The power level of each actor is determined by its size or access to resources, customer dominance, perceived quality of offering and so on (ibid.).

2.1.3 Innovation from INA perspective

The Industrial Network Approach (INA) recognizes that companies operate within a network comprising various actors, resources, and activities (Håkansson & Johanson, 1992). The network perspective further recognizes that companies are incomplete in terms of having all the necessary resources, necessitating interactions with other companies such as suppliers and customers to sustain themselves. These interactions enable companies to access resources and activities that they do not possess themselves. The interconnectivity of the network suggests that any alteration or advancement impacts not just individual companies but also other actors, resources, and activities within the network.

Hence innovation is also viewed as a result of interactions among multiple actors within the network, rather than the work of a single company (Håkansson & Johanson, 2016). It can be examined as shifts in relationships, connections, and affiliations, or as novel configurations of actors, resources, and activities. (Axelsson & Easton,

2016). This perspective highlights three key arguments: knowledge development, resource mobilization, and resource coordination(Håkansson & Johanson, 2016). Innovative ideas often emerge at the intersection of different knowledge domains when combined or confronted, for instance, through interactions between producers and users. To materialize and implement these ideas, companies need to relate them to existing products, systems, and organizational solutions, requiring learning, adaptation, and resource mobilization.

Introducing change or innovation from a network perspective is a complex process (Bygballe & Ingemansson, 2014). While networks are essential for innovation, existing combinations can also hinder innovation due to path dependency and the difficulties associated with adaptations. Solutions and resources are interdependent within a network, making it challenging to replace or combine them with solutions developed outside the network. Implementing new solutions that significantly differ from existing ones incurs high costs and requires balancing the benefits for different actors within their existing resource combinations and ongoing activities. Therefore, achieving innovation entails creating a match with actors' resource combinations and activities as well as considering the costs associated with breaking existing investments and fostering learning processes within and between organizations (Håkansson & Waluszewski, 2007).

2.2 Construction Industry and Innovation

The construction industry is characterized by the irreversibility of the time course and the asymmetry in geographical and social spaces, making it more complex than other industries (Liu et al., 2021).

2.2.1 The Business Relationship in Construction Industry

The definition of construction supply chain (Vrijhoef & Koskela, 2000, p. 172) can share the one used in the manufacturing industry: "supply chain is the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer." While supply chain is undoubtedly crucial to the effective implementation of the construction projects (see the Figure 2.3), it is increasingly clear that the focus on buyer-seller relationship is not sufficient on its own to address the challenges facing the industry.

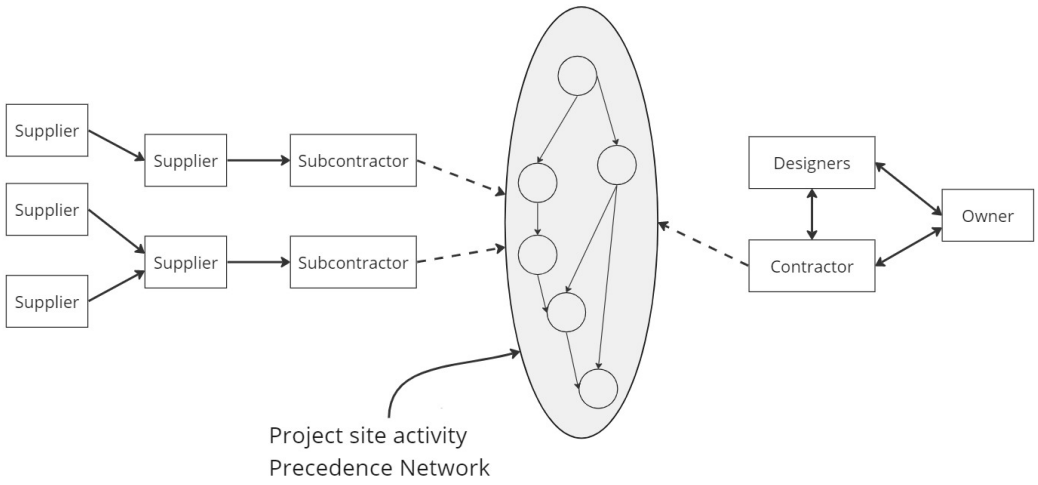

Figure 2.3: A conceptual perspective of the construction project supply chain, adapted from the article (O'Brien et al., 2002).

Gadde & Dubois (2010) described the feature of relationships in construction as longevity but noncontinuous, low stability and independence which result in a relationship of "typified by market-based, short-term, interactions between independent businesses" (Gann, 1996). Longevity but noncontinuous relationships are common in the construction industry, where buyers and suppliers have intermittent and irregular interactions rather than continuous transactions found in high-involvement relationships. The nature of construction projects, being one-off in nature, prevents the development of long-term business relationships, leading to uncertainty and frequent switching of suppliers by buyers between projects. Low stability characterizes relationships in construction, driven by the industry's desire to avoid dependence on specific partners. Construction firms prefer having multiple interchangeable suppliers to reduce uncertainty, avoid being locked into a single supplier's solutions, and foster competition for better prices. These characteristics give rise to what is known as "low-involvement relationships" or relationships with an "arm's-length distance." Independence from business partners is a key aspect in construction, which results in a lack of adaptations to individual counterparts and the missed benefits that such adaptations can bring. While each construction project is unique, standardization is primarily applied to components and materials exchanged within the "permanent network," while the project and site necessitate numerous adjustments and adaptations within the "temporary network."

The relationship and interaction pattern with site-based operations, project-centric business models, and temporary supply chain in construction industry result in mistrust and skepticism embedded in adversarial behavior and conflict among the actors (Fearne & Fowler, 2006; Dainty et al., 2001; Holt, 2015). As illustrated in Figure 2.3, actors like subcontractor and contractor are connected for conducting a specific project on a specific site, where their activities and resources are linked temporarily. Due to the ever-changing coalitions formed around unique projects (Holmen et al., 2005), learning from previous projects becomes challenging to leverage in the construction industry. Additionally, the expectation of future interaction is typically

low due to the project-based nature of the industry. The short-term focus on price often leads to confrontations and the lack of trust contributes to inefficiencies in construction projects (Ngowi, 2007). The reluctance to adapt and dependence on individual partners constrain mutual orientation, as firms prioritize price competition and alternative suppliers. Construction firms are generally hesitant to share technical knowledge and tend to prioritize cost-driven and potentially adversarial relationships, favoring market-based approaches (Bresnen & Marshall, 2000). The variations in adaptation, interaction, and mutual orientation can be attributed to institutionalized norms and behaviors within the construction industry, which are primarily influenced by project decentralization and competitive tendering characterized by purchasing transactions. (Gadde & Dubois, 2010).

2.2.2 Construction Innovation: Lack of Industrial Network

Innovation in construction is considered complex, nonlinear, and dynamic, encompassing both technological and non-technological innovations (Ozorhon, 2013). Being a project-based industry, current construction innovation is more on "hidden innovations" that arise from practical engineering challenges and are achieved through collaborative efforts across firms (ibid.). Construction projects always involve different economic logic and the complex patterns of interactions among numerous actors involved. The innovation often occurs not within individual firms, but rather as part of the projects in which multiple firms and parties are engaged (Bygballe et al., 2014).

Base on the feature of construction innovation above, incremental technological change in the industry may be supported by governance systems involving cross-holdings among industrial firms, which can facilitate long-term relations and collaboration between them (Miozzo & Dewick, 2002). However, as mentioned in the previous part business relationship, the prevalent focus on price and competitive bidding culture leads to frequent changes in actor constellations across projects. This constant shifting hampers continuity and long-term progress, resulting in loose couplings among construction actors and an inability to leverage network effects for enhancing productivity and innovation (Dubois & Gadde, 2002). Inadequate collaboration across organizations has been identified as a contributing factor to the low level of innovation in the construction industry(Holmen et al., 2005). Construction companies are still highly isolated organizations, due to the skills, knowledge and competition-intensive nature of their work (Bygballe et al., 2014). According to the surveys in both Norway and Sweden, the major driving forces of innovation (in addition to the customers) are the internal staff, the own personal network or that of other units within the internal organisation (Orstavik et al., 2015). The external network and supplier relationships seem to be under-exploited resources and suppliers or subcontractors are not highly valued as partners (Bygballe et al., 2014).

The significance of inter-firm relationships for innovation in the construction industry suggests that adopting a network perspective could be valuable in comprehending innovation dynamics within this context (Bygballe & Ingemansson, 2014). With

the aim of promoting green construction logistics effectively, a conceptual model of construction logistics system is proposed to present the interaction among different actors at different levels. As presented in Figure 2.4, three major groups of actors covering municipality, developer and contractor are categorized and positioned at their respective working phase or subsystem. The application of industrial network perspective in this case present a functional system based on the demands and supply of resources. Compared with the construction supply chain depicted in Figure 2.3, the adoption of industrial network perspective here has shed light on the industry with a broader view, which presents more challenges but also more possibilities for collaboration.

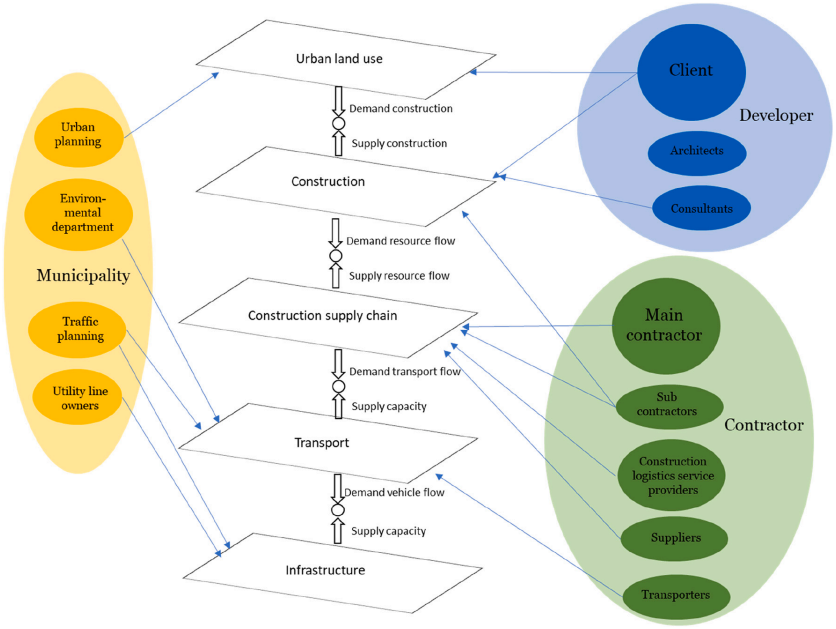

Figure 2.4: Multi-layer multi-actor in construction logistic systems (Fredriksson & Huge-Brodin, 2022).

2.2.3 Electrifying Construction Industry: A Complex Innovation

Due to its inherent complexity, driving the electrification in construction industry requires an innovative approach that takes into account the needs of the entire industrial network. These types of innovations are characterised by integrated collaboration, co-created shared value, cultivated innovation ecosystems, and unleashed exponential technologies with extraordinarily rapid adoption (Dougherty & Dunne, 2011). Aligned with the multi actor analysis (Fredriksson & Huge-Brodin, 2022), the involvement of external actors out of construction supply chain is significant for promoting the electrification in construction industry, since the new resources necessary to the electrification is partially located with the niche/new actors in their core business activities.

Collaborative innovation involving multiple participants has emerged as a complex and competitive strategy, not limited to the enterprise level, to effectively enhance

innovation capabilities(Zhang & Wang, 2022). It refers to the collaborative efforts among independent firms to gain a competitive advantage by exchanging and sharing information, knowledge, ideas, expertise, technology, and opportunities, leading to the generation of novel innovations that may not be attainable individually (Skippari et al., 2017). Collaborative innovation network can be used to boost electrification through enhancing knowledge flow and collaboration across firms. A collaborative innovation network is a specific type of network structure that facilitates collaborative innovation among a group of individuals or organizations and it facilitates knowledge sharing, interactive learning, and the flow of information among stakeholders, leading to enhanced collaboration and innovation (Zhang et al., 2023). Collaborative innovation networks provide opportunities for stakeholders to complement existing resources, facilitate knowledge flow, and drive innovation in the construction industry.

Pilot projects are frequently employed by project-based firms and serve as an effective approach for collaborative innovation within the construction industry. Frederiksen & Davies (2008) mentioned pilot project can be used as a path to a novel entrepreneurial venture for innovation activities. de Melo et al. (2021) further discover pilot projects can play a significant role in the adoption of new technologies and the creation of continuous products or experiences for clients. Pilot policy can be used to boost innovation from the policy perspective. Innovation pilot policies aims to foster urban innovation activities and improve urban innovation capabilities (Zeng et al., 2023). These policies have been widely acknowledged as drivers of regional economic growth and enhanced innovation capacity. Research demonstrates that innovation-city pilot policies positively impact knowledge flow efficiency, urban entrepreneurial activity, optimization of urban industrial structure, finance development, and urban innovation. The mechanism behind these policies involves increased investment in innovation elements within pilot cities, enabling collaborative innovation between universities, research institutions, and enterprises.

2.3 Networked Business Model

2.3.1 The Concept of Networked Business Model

The definition of business model (BM) is proposed in a various way but mostly falls on value capture taking the perspective of a single firm . BM is commonly perceived as a set of managerial practices for tracking the logic of value creation in an organisation (Pekuri et al., 2013b). Exemplified in project-based firms, it is noticed that strategy and operation in an organisation are linked by business models, which map out needed activities to create value for stakeholders (Pekuri et al., 2013a). It is consistent with the understanding that a focal firm's business models is a systems of activities, engaging all kinds of resources to fulfil a specific purpose. (Rajakallio et al., 2017).

Compared with other sectors, business model is found to be a scarcely researched

topic in construction industry (Abeynayake et al., 2022). A study suggests that there is only a partial understanding of the concept leading to insufficient value capture of operating construction companies (Pekuri et al., 2013b). Hence a primary conceptual model is proposed, trying to form a common language to discuss business model in the industry. As presented in Figure 2.5, a bundle of products or services (offering) are provided to deliver construction projects (value creation system), which consists of many specific activities and resources for the execution of project. Notably, this research considers that firm or project level business model is not practical for construction companies usually working on various types of projects, instead, the business model is encouraged to be investigated at the level of business segment and operation. Kujala et al. (2010) even declared that the business model analysis of project-based firms should be conducted at level of individual solutions rather than the firm or project level. It could help create a clear value propositions, which is always presented as a challenge for project-based firms once without a specific context.

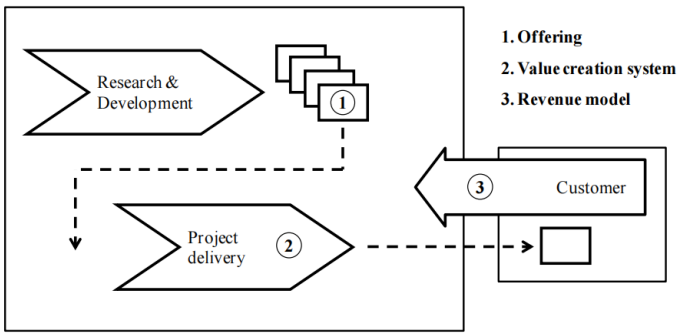

Figure 2.5: A concept of business model in the context of construction industry (Pekuri et al., 2013b).

In general, the theoretical focus on individual companies' value creation is common, and also in practice: firms tend to adopt strategies individually, merely satisfying the demands of their direct customers (Hearn & Pace, 2006). But no one do business alone so companies are always connected by their BMs at least in some way (Pekuri et al., 2013a). An interactive view of business models between different actors is increasingly considered essential, especially for developing new business models (Bankvall et al., 2017; Lindkvist et al., 2023; Lind & Melander, 2023). Magretta (2002) argues that new business models should prioritize building long-term relationships and switch from focus on firm-level to a network-level focus. A shift toward thinking more about value ecology, instead of the value of an individual supply chain, is paying more attention on co-creators of value and complex coopetition (Hearn & Pace, 2006). As pointed out, supply chain is not a chain of businesses with dyadic relationship, but a network consisting of multiple businesses and relationships (Lambert, 2008; Palo & Tähtinen, 2011).

Hence the boundary of BM is pushed further and it is suggested that the adaptation to innovation should be explained in BM as well (Magretta, 2002). BM can also function as a tool to describe where does a firm is located at in a value network (Chesbrough & Rosenbloom, 2002). This is where the concept of a networked

business model comes in. A networked business model presents how a business net creates value in a strategic way (Palo & Tähtinen, 2011), aiming to maximise the whole value of co-creators (Hearn & Pace, 2006). The proposal of networked business model admits that a single firm can not have a control over all relevant resources in its development (Gadde et al., 2003). It can help facilitate collaboration and communication among stakeholders across organisations, paving the way for the adoption of innovation and future business models (Palo & Tähtinen, 2011).

The networked business model is also specified to modular services created by multiple actors. As illustrated in Figure 2.6, a network of actors co-produce and deliver the services to satisfy the needs of customers (Palo & Tähtinen, 2011). The technology-based services consist of various modules so the concept modular service is used here to emphasize the modularity, which is considered advantageous in the development of service and networked business model (ibid.). Another two features in the framework are the involvement of customer in service production net as well as a dynamic nature of the networked business model.

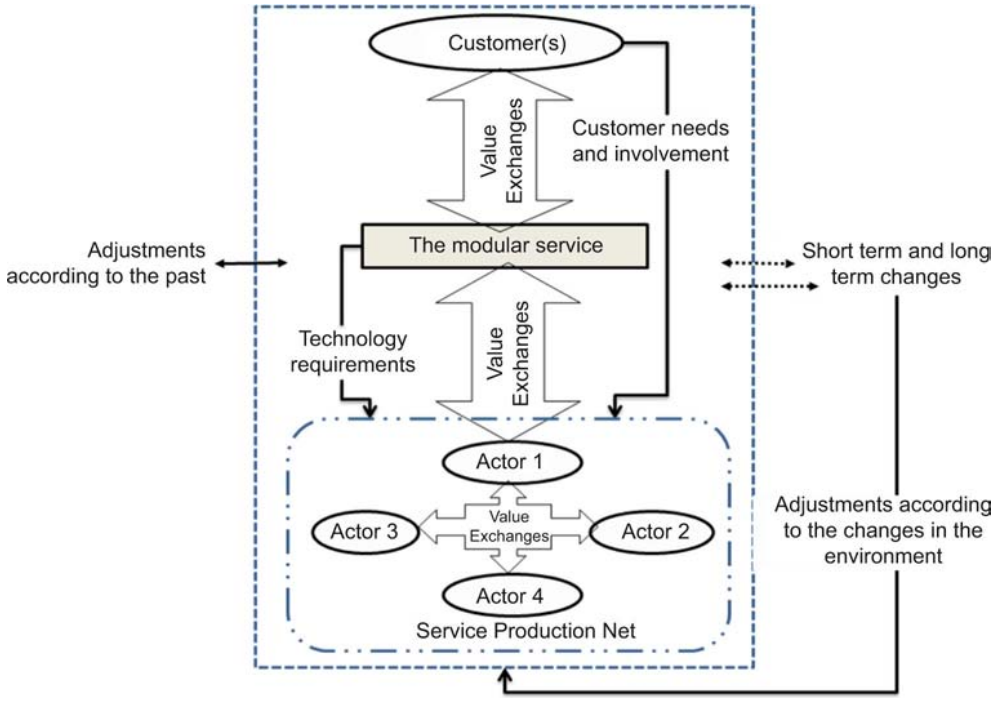

Figure 2.6: The elements of a networked business model (Palo & Tähtinen, 2011).

2.3.2 Development Framework of Networked Business Model

In order to navigate the journey of establishing networked business model for emerging technology-based service, an empirical framework is proposed emphasizing the significance of business net and opportunity (Palo & Tähtinen, 2011). As shown in Figure 2.7, networked business model will experience different phases with a growing certainty in business actors and technology. This framework jumps out of the focus on a single firm (Palo & Tähtinen, 2013), based on the understanding that the development of technology and related services require diverse activities and resources from a network of both commercial and non commercial actors. Instead, the

development of business net and opportunities are considered as pivotal elements for forming networked business model. In pilot phase the term entrepreneurial actor are adopted but the emphasis is on the diffuse of the role across organizations rather than an individual (ibid.).

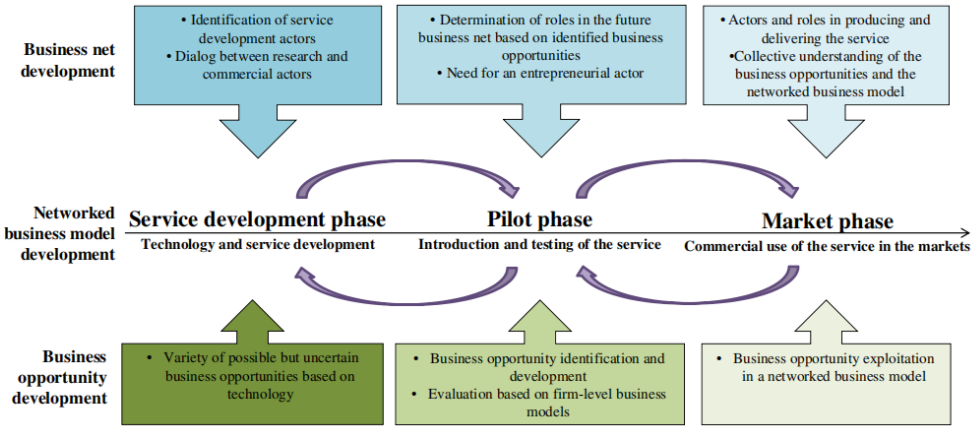

Figure 2.7: The empirical development framework of networked business model (Palo & Tähtinen, 2013).

Looking more closely at the identified phases, service is the analysis unit here and will go through the development phase, pilot phase and lastly market phase in an sequential and iterative manner (Palo & Tähtinen, 2013). The collaboration occurs mostly among research institution, university and companies at the service development phase. Moving toward pilot phase, an entrepreneurial actor might be needed to guide the evolution of the actor net. During the phase the evaluation still lies on the extant and firm level business models of each actor, where a focal actor need to reconcile the disagreement on business opportunities. When it comes to market phase, a collective understanding of responsibilities and business opportunities is established among the net of actors, and the business model is opening for trials and acquiring new actors.

2.3.3 Integrated Solution and Value Co-creation

Integrated solution is one of research sub-fields of servitization, which originally refers to the movement from products towards "bundles of customer-focused combinations of products, services, support, self-service, and knowledge"(Vandermerwe & Rada, 1988; Kohtamäki et al., 2018). As one of advanced services, the integrated solution is defined in various way, but a basic understanding is shared that a strategic and unique combination of products and services is provided to solve a complicated problem taking a customer-oriented perspective (Evanschitzky et al., 2011; Brady et al., 2005b; Lazarevic et al., 2019). Brax & Jonsson (2009) further specifies the definition by adding that integrated solution incorporates the provider as customer's business system in a long term, with the aim of optimizing the total cost for the customer. The reasons behind the trend of servitization and integrated solutions are increasing market competition and shrinking profits (Windahl & Lakemond, 2006). New strategies are needed to propose more value for customers, and many project

based firms extend their delivery scope by integrating more activities and providing integrated solution (Wikström et al., 2010). Beyond traditional project deliveries, they offer the services of maintenance, spare parts and management, even partially own a enterprise run and operated together by multiple actors (ibid.).

Some experts suggest that the future of the construction industry relies on embracing a new business model centered around integrated solutions(Brady et al., 2005a). The potential of integrated solution in construction industry can be evidenced by the success of Hilti Fleet Management for construction projects (Casadesus-Masanell et al., 2017). Starting from the manufacturer of construction tools, the company Hilti has been selling their products directly to construction companies. Since 2000, the company proposed a new business model by providing an integrated solution termed fleet management to their customer or construction companies. A life cycling management of construction tools is packaged including the financing, renting, maintenance, coverage for theft, an online tracking system as well as recycling at the end. The new proposal works effectively in terms of a surging revenue since 2000 (Casadesus-Masanell et al., 2017). In this case, the demands of construction companies that is to focus on their core business activities are satisfied.

Above all, a lack of motivation to spend time standardizing solutions can be identified in construction industry (Buser & Carlsson, 2015), and the introduction of private finance initiative in the requirement of public clients is considered a good context to develop and provide integrated solution (Brady et al., 2005a). It can be understood from the involved complexity that the provision of integrated solution might need firms to take over the service activities from their customers as well as conduct completely new activities (Brady et al., 2005a). Therefore, in the phase of developing solutions, the firm's resources and competence are equally important to the customer's insight (Storbacka, 2011). Then the solution can be provided to create value for both provider and its customers. Developing integrated solution lies on whether the organizations can create the effective solution package to meet the increasing demands of their customers (Davies, 2004). And it can take many years for a single firm to build up all needed skills and competences (ibid.). Windahl & Lakemond (2006) shows that a close operation with customers and external actors is one of essential success factors of developing integrated solution.

When a single company lacks the ability to solve a customer problem on its own, it seeks complementary resources through partnerships. These actors then collaborate and utilize their resources through interaction to co-create value within networks (Hakanen, 2014). Ramaswamy (2009) defined value co-creation as "the process by which products, services, and experiences are developed jointly by companies and their stakeholders, opening up a whole new world of value" . Ind et al. (2013) indicated this process involves fostering collaboration among various organizations and stakeholders, aiming to generate mutual benefits and create substantial value for all stakeholders involved. This broader outlook pertains to service ecosystems, which can be defined as interconnected networks of actors who integrate resources, operate within shared institutional logics, and engage in mutual value creation through ser-

vice exchange (Vargo & Akaka, 2012). In fast-changing environments, implementing a value co-creation strategy empowers firms to cultivate capabilities in knowledge exchange and combination (Khanagha et al., 2017).

All actors within a network, including focal firms, suppliers, customers, and other business partners, possess the potential to become co-creators of value in collaborative innovation. When partners and firms engage in a value co-creation process built on trust and mutual commitment, it has the potential to create a positive cycle of co-creation (Niesten & Stefan, 2019). Additionally, as emphasized by Re & Magnani (2022), the collaborative creation of value between firms and partners leads to the implementation of joint projects, enhancing brand awareness and reputation among clients and society at large. Regarding public institutions, Ansell & Torfing (2021) argue that value co-creation between private and public actors can facilitate problem-solving processes. Furthermore, De Silva & Wright (2019) emphasize that firms collaborating with public entities such as universities and government bodies not only generate innovations but also create both business and social value.

Value co-creation in servitization can be seen as a process that provider and customer both play an active role in creating value through direct interaction (Grönroos & Gummerus, 2014; Sjödin et al., 2016). Servitization involves utilizing relationships to comprehend customer processes and goals, striking a balance between the customer's specific circumstances and the offerings of the servitizing company and this process entails involving customers in the creation of personalized solutions. Mutual value is co-created in this interactions between provider and customer.Value co-creation is significantly impacted by collaborative innovation (Al-Omoush et al., 2023). Organizational value creation is dependent on innovation capabilities, which allow for the development of new capabilities and the addition of fresh value. Collaborative innovation, involving shared and cooperative co-creation processes, is instrumental in enhancing value creation. Value co-creation requires diverse collaborative activities among interdependent partners, contributing to innovation processes and creating value for all partners involved (Sayyadi Tooranloo et al., 2018).

Successful collaborative innovation encounters a significant challenge in the form of heterogeneous partners within innovation networks who possess conflicting interests and motivations for engaging in collaboration. To achieve fruitful value co-creation through collaborative innovation, it is crucial for firms to collaborate with willing business partners who demonstrate trustworthiness and reliability (Al-Omoush et al., 2023).

3

Methodology

This section describes the methods for the thesis. To address the research questions, a qualitative research design was selected, which was divided into three distinct phases. In the first phase, data was gathered through a combination of expert interviews and literature review. In the second phase, the business network for construction industry was analyzed as well as challenges and probabilities based on the input of data collection. In the last phase, networked business models were proposed. Figure 3.1 presents an overview of the methodological procedure employed in this thesis.

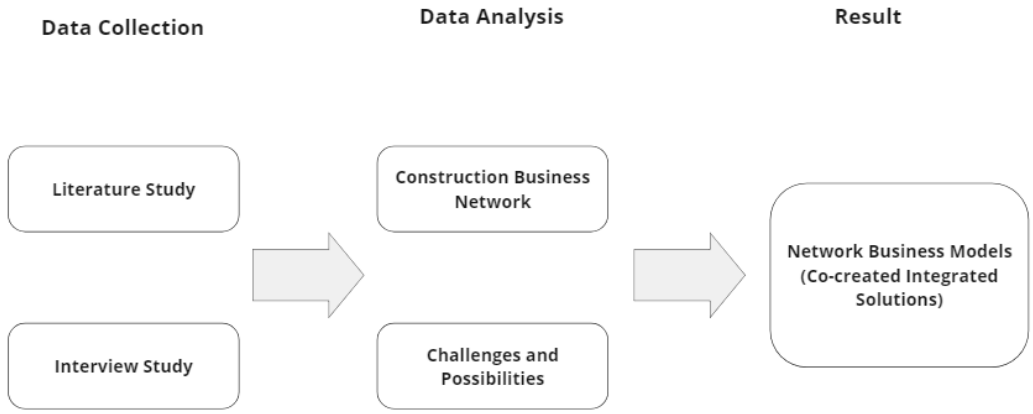

Figure 3.1: Research methodology overview

3.1 Literature study

The process of reviewing literature commenced early on and persisted throughout the data collection stage. According to Bell et al. (2011), it is imperative to undertake a thorough literature review to establish a linkage between the research questions and the extant literature. This crucial phase involves a meticulous reading and analysis of relevant literature, which enhances the credibility of the study and provides a comprehensive understanding of the existing knowledge in the chosen research domain. To this end, we primarily utilized the reliable sources available on Google Scholar and the Chalmers library database, and evaluated the references

based on their citation counts. The search for pertinent literature was conducted using the following keywords:

- The promotion of electrification in construction industry
- Business models and innovation in Construction industry
- Industrial network perspective about construction supply chain
- Networked business model and integration solution

3.2 Interview study

Expert interviews is used as a method of qualitative social research for this thesis. The expert interview is a commonly utilized method in empirical social research that offers unique perspectives into expert knowledge, structural contexts, and processes of action systems. Its purpose is to uncover elusive "insider knowledge" possessed by individuals (Bogner et al., 2009), with the goal of conducting efficient and effective interviews. The expert interview has gained widespread acceptance among professionals (Bogner et al., 2009).

In total, 17 respondents specialising in different areas of construction industry have been interviewed, as shown in Table 3.1.

ID	Organisation	Role
M1	Municipality A	Innovation strategist electrified transport
PIA1	Public Innovation Agency A	Director of innovation department
RA1	Regulation Association A	Project manager in procurement
EON1	Electrification Collaboration Network A	E-mobility Expert
IC1	Innovation Center A	Project Manager
OEM1	Large OEM A	Researcher in Site Application Analysis
LCC1	Large Construction Company A	Vice President Innovation
LCC2	Large Construction Company A	Project Manager
LCC3	Large Construction Company A	Project Manager
LCC4	Large Construction Company B	Project Leader
LCC5	Large Construction Company B	Site Manager
LCC6	Large Construction Company B	Project Leader
SCA	Small Construction Agency A	Owner of the company
RI1	Research institution A	A.P. in Communications and Transport Systems
RI2	Research institution A	PhD student in Communications and Transport Systems
RI3	Research institution B	A.P. in Construction Management
RI4	Research institution C	Professor at Construction Management

Table 3.1: Overview of the interviews

To more effectively extract the insights of specialists, semi-structured interview is used as the interview method. In qualitative research, the concept of immersion is commonly discussed, which refers to the researcher's involvement in interacting with the study's subjects to gain insights into a social setting (Bell et al., 2011).

A semi-structured interview is a prevalent method for this interaction, as it allows the researcher to maintain an open mind towards the research question and theory (Bell et al., 2011). The semi-structured format strikes a balance between flexibility and comparability and allows for the emergence of unknown themes by enabling participants to go off script.

Initially, the researchers were provided with a list of potential interviewees from their contact at the local companies, who were then contacted via email to arrange interview dates. If there was no response, the researchers followed up with a email. The snowball sampling technique was used to expand the pool of interviewees. As described by Bell et al. (2011), snowball sampling can be effective when a sampling frame is difficult to define, or when the concept of a representative population is not applicable. In this case, interviewees were asked to refer other individuals who could provide relevant insights. This approach enabled the researchers to gather a diverse range of perspectives from individuals who were knowledgeable about the topic under investigation.

The interviews were conducted using a combination of face-to-face meetings and virtual video streamed meetings via Microsoft Teams. Initially, the preference was to conduct all interviews face-to-face due to the potential for more personalized engagement and nuanced discussions (Bell et al., 2011). However, in cases where respondents were geographically distant, had time constraints, or preferred virtual meetings, Microsoft Teams was used as an alternative. In addition, the use of Microsoft Teams allowed for some visual engagement, thus facilitating observations of the interviewees to some extent.

Consent was obtained from each respondent before recording the interviews, enabling the authors to capture exact data for analysis. With the exception of one interview, both authors were present during each interview, which aligns with the recommendation of Bell et al. (2011) for multiple interviewers to take extensive notes and intervene as needed. The presence of multiple interviewers also contributed to more in-depth discussions and richer answers. To optimize the interview process, each author had a specific role: one led the interview, while the other took a more passive role, responsible for taking notes and asking follow-up questions.

A structured interview guide was developed to facilitate the formulation of interview questions. Questions were customized to suit each individual's professional position. The interview questions are available in the report's Appendix. The interviews were conducted in a neutral manner, with no evaluation of the answers to determine which were superior.

3.3 Networked business model development

The structure of the chapter analysis and result is inspired by the conceptual model proposed in the article (Palo & Tähtinen, 2013), following the steps of analysing

network of actors, identifying opportunities and challenges, and finally proposing networked business model.

3.3.1 The Analysis of Business Network

To analyze the network of actors in the construction industry related to electrification, the analysis of business network was conducted. This method is used to identify the key actors in a network and their relationships, as well as the flow of information and resources among them. Data for the actor's network analysis was collected from the expert interviews, literature case study, and publicly available data on the construction industry. The data was then analyzed using INA framework to identify the key actors and roles in the network, as well as the flow of activities and resources among them. The results of the actor's network analysis provided insight into the key actors and relationships that are critical to the electrification of the construction industry.

3.3.2 Identify challenges and possibilities

To identify the challenges and possibilities of electrification in the construction industry, data from the expert interviews, literature case study, and actor's network analysis were analyzed. These barriers and challenges were analyzed and compared across the different data collection methods to identify commonalities and differences. Value of potential business were identified and confirmed from current challenges and possibilities. New business models were designed to solve existing barriers of electrification as the process of value creation and capture.

3.3.3 Propose Networked Business Models for Electrifying Construction Industry

Drawing from expert interviews, literature case studies, and actor's network analysis, innovative business models have been proposed to facilitate electrification in the construction industry. Integrated solutions are found to be highly valuable. These models are designed to tackle identified barriers and challenges while capitalizing on the potential and solutions offered by electrification. By incorporating principles of collaborative innovation and value co-creation, these networked business models aim to gently encourage the industry to embrace electric equipment without overwhelming existing incumbents. The goal is to create a conducive environment for increased adoption of electric solutions while respecting the industry's custom and stakeholders' interests. The scope and future prospects of these proposed business models are examined and discussed, providing insights into their potential impact on the industry.

4

Empirical Findings

This section is to present the data and information collected from expert interviews. A storytelling style is adopted (Reeves et al., n.d.) following the line of observing the current electrification in Swedish construction industry, making sensing of the current situation by understanding the struggling points, and finally presenting experts' suggest for future development.

4.1 The Electrification of Swedish Construction Industry: Where Are We Now?

The electrification of Swedish construction industry is gaining more attention in recent years. As pointed out by Researcher RI3, the manufacturing of electric equipment has been questioned since a large amount of materials and energy are consumed to build the battery part, leading to more emission than producing alternative combustion engine. But in recent years, the improvement in battery technology, energy production and the application of life cycling thinking has made several countries especially Sweden become more supportive toward electrification in construction industry. In addition, the increasing awareness of sustainability in Swedish construction industry is also bringing more focus on the electrification. The most interesting area is urban development since there is more strict requirement on emission and noise reduction.

> *There have been a bit hesitation to develop the machines, but the last five years there's been really a push for it and I believe that lots of the suppliers or the manufacturers of machines are interested in finding new series and a bit of a race in that right now.* — Vice President Innovation LCC1, Large Construction Company A

> *Once the electrification is successful, there is no reason going back to combustion engine since electricity is cleaner for both environment and people's hands.* —Project Manager LCC2, Large Construction Company A

However, the market is not going hand by hand with the improvement in technology and awareness of sustainability. Although small electric cranes, lifts, and vehicles have been available for a while, there is still no commercial electric worksite in Swedish construction industry. From 2022 sustainability reports of some major construction companies, it can be informed that, while there is intention to push more electrification in their finance plan and policies, so far no fleet of electric machinery is employed for ongoing construction projects in Sweden. The efforts put in developing and testing electrical technology also varies among construction companies, covering electric truck, electric machinery, charging infrastructure and dynamic charging road. In terms of the number of electric equipment in use, electrifying off-site transportation is gaining more momentum than the proliferation of on-site electric machinery.

> *The technology is already advanced enough, but more company need to use them and for this to happen there must be a more broad discussion about those electric machines.* —Researcher RI3, Research institution B

In this case, a systematic and organized guidance of who can do what to promote the electrification is still missing in current literature and reports. There is also no any solid national strategy for implementing electrification in Swedish construction industry let alone the specific electrification requirements on different actors. In contrast, Norway is leading the trend of electrifying construction sector by setting several ambitious targets. In Oslo, a public procurement strategy published in 2017 requires all municipal construction projects to adopt zero-emission construction technology or electric equipment. By the following year a joint statement between municipal and national level government declared their intention to request electric technology for all future construction projects . The use of public procurement to help motivate market has been further pushed by incentivising the purchase of electric machinery and installment of electricity infrastructure. For example, Norwegian business development agency Enova has launched two programmes to subsidize 40% of additional costs of electric alternative as well as 40% for the investment of mobile charging stations.

> *Who will have the benefits, who will have the cost that is not clear right now. And for that, the research is needed to create awareness like who will get what and in what way they can create benefits for all actors.* — RI2, Research institution A

4.2 Struggle in the Change: Networking and Motivational Obstacles

The current market situation of electrification in Swedish construction industry can be understood mainly from two aspects: lack of collaborative network and lack of motivation.

4.2.1 Lack of Collaborative Network

The work differentiation and competition for winning the contract have segmented the whole industry into a large amount of specialized companies. As shown on the construction sites, there are always many companies to transport materials and build different parts of the project. Such complex component of actors can lead to a slow absorption of new technology. As evidenced by RI2 from Research institution A, the standardization of some widely adopted technologies like booking calendars and tracking system is even presenting as a challenge in the industry at the moment.

> *I was there for like 11 days. And I couldn't like keep account of their number of transport that was coming in, it is an unlimited is infinite. I cannot make a connection like which transport is for which supplier and which is coming for which it is very difficult to understand that.* —PHD student RI2, Research Institution A

The under-utilisation of technology and full of competition make it difficult to form a collaborative network across those actors with different economics logic. Without a platform of information sharing and collaboration, the network issues also appeared within construction companies. Project Manager LCC2 and LCC3 from Construction Company A informed that projects under their company are not connected well. They explained that projects distributed at different geographical locations belong to different clients, who negotiate and give requirement to local department of the company. Then it is likely to end up in the situation that the process of finding the right suppliers is repeated and even similar requirement are given between these projects. So in order to collect more information about electrification, two of them are working on establishing an internal network or platform to gain the competition over other companies, which is different to the broader industrial network across actors that has been discussed so far in this research. It is also stated by Director of Innovation Department PIA1 that, compared with OEM company and other suppliers, Swedish construction companies are not interactive in strategy conversation involving addressing the electrification and other issues.

> *The construction sector is full of contradictory, non-network mechanisms, they are competing with each other trying to protect certain market shares.* —Professor RI4 at Construction Management, Research institution C

> *As long as we can do that in our own business, we are not helping the external subcontractors gaining experience.* —Project Manager LCC2, from Construction Company A

Instead of a collaborative network, an archetypal network is formed consisting of a few bigger actors consolidating lots of small actors. The system is functioned by a vertical relationship throughout major actors including client, contractor and subcontract. It can explain for the understanding of Construction Company B that,

if more implementation of electrification is expected, either client should demand electric equipment or supplier should provide them. They focus on maintaining their margins, waiting for other actors' movement as well as a more mature market of electric equipment. The major issue of electrification for them is that the client would be willing to pay the extra cost for using electric equipment. This is aligned with the opinion of Researcher RI1 that clients and contractors usually become the ones paying for extra services, but they can not see as much benefit as city can.

> *Large contractors do not own their own site equipment, so if they want to have a light on their site, they hire the light. Generally speaking, there are always someone who own it.* —Professor RI4, Research institution C

> *We only act like a spider in the net, helps the site managers with things they need. And also helps companies that own excavators and truck to get construction work. Since we do not own anything ourselves we can´t affect if someone quit their job. In addition, the customer decides how it will be and we only follow* — The Owner SCA, Small Construction Agency A

Everyone is waiting for everyone, and the dyadic relationship in the existing network seems not to be ready for electrification. There is a vicious loop observed by Professor RI4 that client put up the demands for electric machines, but contractors do not have them. As a result, clients claim that they can not electrify construction site and contractor says that clients are not giving requirements. It is also acknowledged by Large Construction Company B that regulations from the government may require the use of electric machines, then the industry will be willing to comply. By that time perhaps everyone has to give up some margins for the sake of environment but not specially one or two actors. However, the change of regulation can be slow due to some political factors. A long term plan is also not common in Sweden. As clarified by Director PIA1 from Public Innovation Agency A, it does not mean the long term goal is shifted. It only means that the country might not be able to move as fast in that direction as original expectation, or there is a need to combine different initiatives so that the country is still moving in that direction.

> *It's difficult to incorporate the new type of business model parallel to the major one: how they are doing their business today in construction industry. It becomes almost like a vertical model where someone have to buy a project and then you can build services on top of it.* —Director PIA1, Public Innovation Agency A

> *No one really wants to be the first one to invest in this because no one really knows if they will have any return on that investment.* —Researcher RI1, Research institution A

4.2.2 Lack of Motivation

Apart from the inherent characteristics of the industry, there is also a lack of motivation to promote the electrification for several reasons. First of all, the high investment of employing electric equipment is bringing the transition to reality. Provided by Professor RI4, the price of electric alternative almost double the diesel driven ones. No actors have the reason to undertake the costs alone. As the major buyers of diesel-driven machinery, subcontractors usually consist of small companies even individual one, undertaking lots of finance pressure if they buy in electric alternative. By investing in the high-cost machines, there is also no obvious benefit for contractors to gain since their core business activity is to ensure the completion of construction project. Notably, emission of machinery contributes to around 10% in the sustainability goal of Construction Company A, giving priority to more emergent area like the production of materials. The insufficient investment in charging infrastructure is another issue especially for off-site transportation. As far as Researcher RI1 known, in Sweden there is no charging infrastructure for logistic trucks to charge on construction site, the priority of construction site charging infrastructure is mainly for the usage of on-site equipment.

> *They want these things to happen, but it is a bit slow because of profitability issues, infrastructure issues and demands by the customers.* —PHD student RI2, Research institution A

> *We cannot just have lower margins just because we have electrified machines.* — Project Leader LCC6, Large Construction Company B

In addition to the finance issues, the transition itself is a complex change. Extra efforts on planning is unavoidable, the most obviously, setting up charging infrastructure is necessary before initiating electric construction projects, which could be a challenge in congested area. What's more, ensuring the capacity of electricity grid even request earlier negotiation with energy department and agencies. After electricity is ready, when and how to charge the fleet of equipment efficiently is another thing to be kept in mind. These issues have not been investigated enough so far, since most of pilot projects are currently conducted in well equipped urban environment involving just a few number of electric equipment. It may not be easy to get power to remote locations. The potential disturbances in electricity grid because of charging construction equipment also remains unknown.

> *You can problematise it and say that it is a kind of resistance to change, but you can also be more appreciative and know that these people actually earn a living from the qualities of their machines and they need to know that these machines are actually performing.* —Professor RI4, Research Institution C

The creation of new knowledge and skills take time to happen. The experience of operating electric machinery is claimed to be almost identical to diesel-driven ones

by operator. But large size machinery like 30 tons can only technically supported by cable-connected charging. In one of pilot projects electric worksite, the introduction of cable still decreased work efficiency a bit, because the cable was moved around to avoid driving over it. An anecdote provided by Professor RI4 is that the operator finally found a way to handle with the cable, that is to rotate the body of machinery making the cable visible in the front, then the excavator pliers can be used to lift it up while driving to another working spot. But it still happened to the pilot project that the machine stopped working for several days because there is no new cable at the hand to replace the broken one. Once the number of working electric equipment is increasing, the issue of cables could be a headache.

4.3 What an Collaborative Business Network for the Electrification could Look Like?

As the construction industry strives to adopt electrification, there is a need for increased innovation within the sector. Some stakeholders and experts have already anticipated the potential challenges and are taking proactive measures to address them. To facilitate this transition, it is crucial for various actors within the industry to collaborate and adjust their competencies and responsibilities, as noted by Professor RI4. Most of the interviewees in this study agree that more collaboration is necessary to achieve the electrification and environment goals, and that countermeasures should be implemented to overcome current struggles. To encourage more innovation in the construction industry, networking and collaboration among stakeholders are necessary, especially given the opportunities for applying electrification in innovative ways . While the transition to electrification is complex, it also presents new business opportunities for actors like vehicle manufacturers, and can benefit the environment in the long run.

> *We always have a network of actors in construction, but it's not necessarily that they are aware of each other or they are connected.* — Researcher RI1, Research institution A

4.3.1 Exploration: Pilot Project

The municipality in Sweden is playing a crucial role in initiating network and collaborations among major actors to explore the feasibility and potential challenges of electrifying construction sites.

Two pilot projects are commenced by Municipality A, involving aligning contractors, vehicle manufacturers, and universities to explore the steps required to electrify construction sites. Project Manager IC1 from Innovation Center A serves as the administrative partner and project manager, overseeing the overall flow of the project and dealing with work packages related to policy issues and business development. The technical and detailed aspects of the projects are the responsibility of actors such as OEM A, Construction Company B, and the Municipality A, while research

institution A and B focus on construction processes, business models, and energy flows. Informed by Innovation strategist from Municipality A, a continuation of these type of projects can be expected. The overall aim is to make procurement requirement when there is a reasonable cost of electric machine in the market. In order to reach the goal, it is considered essential to understand the change in electric grid and the way of working, as well as find a way so that all big and small companies can make the a fair transition.

> *"I asked them about all this fair transition. What effect will be in the electric grid and how they will change the way of working, but they said that's up to the supplier, the construction company. So they don't as we are trying to understand, as I feel, that they will make the demands and then someone else will have to do the transition and they will pay for it, like they are procuring prototypes at extreme costs."* — Innovation strategist, Municipality A

The Electric Worksites project involves testing various construction equipment, from compact to 30-ton machines, with most of them being battery electric. The largest machines will be tested with a direct connection to the cable, which requires cable management on construction sites. The Electra project, on the other hand, focuses on studying the electrification of building logistics, including all transports coming to and from construction sites and the impact of fully electrifying them on both the trucks and the charging infrastructure. Universities are involved in this project, along with Echo Loop, a company in Stockholm that has undertaken several projects around building logistics and electrification. The project aims to consolidate all the results, analyze data and different scenarios, and determine the most effective business models.

> *The use of electric work machines on construction sites, especially for energy-intensive earthworks of various kinds, is an important step for to achieve these goals and to reduce harmful emissions such as air and noise.* — Project Electric Worksite

> *So far, only an insignificant proportion of construction transport is done with the help of electric trucks and it is of great importance to increase knowledge and gain an understanding of how they can be applied in different environments as well as the impact and requirements of electrification from a societal system and construction process perspective.* — Project Electra

Several challenges are identified from the pilot projects:

Cable management
Researcher RI3 found heavy electric machines require continuous plugging in, which affects productivity due to cable management issues. There may also be issues with

standardization of plugs and cables for different types of electric machines used by various subcontractors. He suggested that planning of construction sites needs to consider storage, parking spots, and movement of these machines around each other without stepping on cables.

Grid challenges
Researcher RI3 and Project Manager IC1 point out that the electrical grid may also face challenges if multiple machines are used simultaneously. Researcher RI3 suggests that early involvement of various actors, including those who supply electricity, is necessary for widespread implementation. Expert EON1 from Electrification Collaboration Network A suggested that early talks and cooperation between grid companies and construction companies are crucial for successful electrification of construction sites. The interviewee also highlighted the need for grid reinforcement, which may require proactive planning and analysis of future electricity demand from all construction sites in the city. Project Manager IC1 proposed a idea to prioritize the construction of power grids and charging facilities in construction projects to supply energy to construction sites and consider the commercialization of charging facilities afterwards. Also, Researcher RI1 mentioned in Sweden there is no charging infrastructure for logistic trucks to charge on construction site. the priority of construction site charging infrastructure is mainly for on site equipment.

Short-term demand for Charging infrastructure
Beside the general grid challenges, the short-term need of construction project may require other solutions from limited capacity of the local grid. Expert EON1 believe that battery storage maybe one potential solution for short term electricity need from construction site. It is interesting for construction sites as well since the need is is very locally and temporary. The use of battery storage as a way to address this issue, which can be moved and used temporarily when needed. Expert EON1 mention the potential benefits of using battery storage, such as saving money by charging the batteries at night when the electricity prices are lower and using them during the day when the prices are higher.

> *Swedish truck plants are kind of against the battery swapping technique, they want it charged in a charging station. I'm not saying that that battery swapping will be the best solution forever and ever, but I think we need multiple different techniques for it to take effect in sense* —
> Researcher RI1, Research institution A

Unsaturated usage
Researcher RI3 mention the investment for fully electrified vehicles is significant and does not happen often. The fragmented nature of construction work results in a lot of idle time for machines which can be planned for but cannot be entirely eliminated. Shared economy can help diffuse the cost of investment, but planning is crucial to ensure effective use of these vehicles. Responsibility for planning falls on contractors while subcontractors own the electrical machines.

Few machinery choices
From the case study in Oslo, we can also identify that there are few available electric machinery and vehicles in the market when electrifying the construction site.

4.3.2 Collaboration: Networking Efforts

Other actors also recognize the importance of network and they have been build some network to help innovation from their perspective.

Electricity, a collaboration network originally formed for electric bus, is run by 15 partners from the city, business and academia to promote sustainable and electrified transport. This network aims to provide a real project environment for different actors to test new products and services.

Public Innovation Agency A is Swedish government's Innovation agency, and their role is to help Sweden stay competitive in the global context. The organization tries to encourage construction companies like Construction Company A and their competitors for funding opportunities to address the gap between construction electric equipment and building houses/facilities and more importantly invite those actors in the conversation of electrification regulations and policies.

> *We are trying to get above the transaction perspective and find what are the aims for our company and other company. Could we do something together that will enhance our competitiveness or reach our targets better?*
> — Vice President Innovation LCC1, Large Construction Company A

Construction Company A also plan to have their internal subcontrators focus on eletrification so that they will gain and document good experiences, and identification of needed knowledge. Large Construction Company A believe the experienced internal subcontractors will create a competitive advantage in the future of electrified industry.

> *While we are not waiting for that, we we have our own machine company. Uh, like an internal subcontractor there, also working externally. But we have our own subcontractor within the company. We are not helping the subcontractors Gaining experience. And that is due to the subcontractors are not only helping us, they are helping our competitors too. - Project Manager LCC2, Large Construction Company A*

OEM A contain its network within its customers by collecting design input from key account customers and also performing need finding, which is a design thinking approach to collect information from customers, customers of customers, and operators to identify unmet needs that can be met through radical innovation. OEM A has dealerships in between the company and the contractors who provide construction projects for them to try out their new electric machines. The company also collects

systematic feedback on their existing solutions.

Regulation Association A is an organization that collaborates with municipalities, regions, and companies to promote environmentally friendly practices in the procurement of vehicles, machinery, and fuel. Their role is to act as a facilitator and consultant, assisting public actors in designing climate and environmental requirements for public procurement. Regulation Association A operates on a membership model, where organizations can become members by paying a membership fee. As members, organizations can access the services and expertise of Regulation Association A as a consultant. This consultancy support includes guidance and advice on incorporating environmental and climate considerations into procurement process.

4.3.3 Motivation: potential business opportunities

To increase motivation and accelerate the process of electrification in the construction industry, it is crucial to foster more collaboration and networking among existing actors, and consider bringing in new actors as well. Identifying problems within the network is essential, and it is necessary to align relevant business activities and demands with a construction project to be electrified.

Charging infrastructure provider
The Swedish government has invested in charging infrastructure for electric vehicles, but the focus has been mostly on private cars rather than goods transport. Public charging infrastructure is needed for construction logistics to fully transition to electric vehicles, but the fragmented nature of the trucking industry means there may be queues for charging stations. One example of successful adoption of electric trucks is Stockholm World Seaport, which has received support from the city in terms of infrastructure and long contracts with haulers. Researcher RI1 also mention the truck manufacturers see the potential for business by providing charging infrastructure at their sites.

Rental company
High cost are the barriers to promote electrical equipment. Project Manager LCC2 and LCC3 suggest Rental companies may be a solution for subcontractors who cannot afford the investment and risk associated with buying the machines themselves. Director PIA1 mentioned Large OEM A has considered to provide rental solution for electrical equipment. Professor RI4 further suggest public rental company for the purpose, and points out the importance of the relationship between main contractors and subcontractors who own the machines, and how public-private cooperation in owning and renting out machines could be a possibility to overcome investment barriers.

Incentives
Several researchers mentioned lack of incentives are the barriers to boost the electrification. Researcher RI3 suggest that incentives such as subsidies from public

clients could encourage adoption. The majority of construction work is done by subcontractors who would need to be incentivized to buy electric machines.

Public initial large construction project
Researcher RI3 suggests that public actors should start some large construction projects with encouraging electric machines and vehicles such as city districts, bridges to overcome high cost of electrification, public projects could motivate contractors and subcontractor to procurement electrical equipment and then leads the positive cycle of electrification from one project to another and mature the market.

> *There is possible public-private cooperation. You could establish here which is not really on the agenda in Sweden.* —Professor RI4, Research Institution C

Training and knowledge sharing
To widespread the electrification, the involvement of training institution is suggested. Professor RI4 mentioned The existing knowledge and skills related to diesel engines and the work that they are capable of are deeply ingrained in the construction sector, making it difficult to make the switch. Education, training, and competence development are necessary for operators, site managers, engineers, and others to be able to work effectively with electric machines. There are also concerns about charging and maintenance, as well as infrastructure and cable capacity. Collaboration between different actors, such as energy companies and rental companies, is necessary to address these challenges and facilitate the transition to electric machines. Project Manager LCC2 mentions Large Construction Company A is developing a knowledge hub with similar idea but focus on their inside knowledge share.

Construction Logistic Center (CLS)
CLS is suggested from Researcher RI1 by developing a logistics center to use electric vehicles and build charging infrastructure there to electrify the last mile of transportation to the construction site, as well as exploring opportunities to combine the need for charging construction. Stockholm has been successful in building logistics centers, which are appointed as the building logistics center for a whole area. All transports to that district go through this facility to minimize traffic movements within the construction sites and the whole district area.

Grid supplier early Involvement
Expert EON1 emphasizes that access to electricity is a major issue in cities, where most of the electricity demand is centered and where many construction sites are located. He suggested that early talks and cooperation between grid companies and construction companies are crucial for successful electrification of construction sites. He also highlighted the need for grid reinforcement, which may require proactive planning and analysis of future electricity demand from all construction sites in the city.

Regulations and policies speed
Expert EON1 also identifies that regulations and policies need to keep up with the rapid changes in electrified systems. Policy changes can happen quickly, but this is not always the case. Decision-makers have limited time to make changes and there is a priority list of issues to address. Additionally, policy changes are difficult to know what the implications or effects of the changes will be. The process needs to be quicker because if it takes too long to change policies, there may only be one try, and it might be too late to make a difference. According to Regulation Association A, Sweden is considered a relatively small market from the government's perspective. As a result, they believe that policies and initiatives related to promoting environmentally friendly practices in the transportation sector heavily rely on support and regulations at the EU level.

Construction companies actively involvement
Director PIA1 mentions some construction companies like Large Construction Company A or Large Construction Company B are not very involved in innovation because they are not engaging in strategic conversations with Public Innovation Agency A and other governmental agencies, which could provide them with funding opportunities. These companies could influence the calls that Public Innovation Agency A puts out if they had more interactions with them. It might be a habit-based issue where they are not used to seeking governmental funding, or it could be that Public Innovation Agency A needs to communicate better with them to make them feel invited.

Subcontractor management
PHD student RI2 thinks the construction industry lacks communication, collaboration, and information sharing among the actors across the supply chain. There is a lack of integration of technology, and the use of booking calendars is not standardized, making it difficult to coordinate and plan deliveries. There is also a lack of data recording, with many construction projects not recording delivery times or CO2 emissions. Additionally, there is no logistics manager on construction sites to manage deliveries, and the construction managers are focused on completing the building rather than managing deliveries. While the use of tracking technology could reduce costs in the longer term, the construction industry is not currently utilizing it. She suggest construction company should build a network to manage the suppliers.

5

Analysis and Results

Based on the development framework of networked business (Palo & Tähtinen, 2013), this chapter analyses and discusses empirical findings combining synthesized theories following three steps: business network, opportunities & challenges and networked business models, in the context of promoting electrification in Swedish construction industry.

5.1 Business Network in Construction Industry

Drawing upon empirical findings and theories, there are two kinds of perceptions about business network toward electrification in Swedish construction industry: a vertical structure and a collaborative business network.

5.1.1 Traditional Construction Business Network

Instead of depicting the feature of construction industry only as the hurdles toward the absorption of electrification, the high efficiency of the vertical structure among actors is also acknowledged here (Rajakallio et al., 2017). From the INA perspective, the main actors including client, contractor and supplier are defined by their controlled resources and activities (Axelsson & Easton, 2016). In order to implement construction projects efficiently, a structural way of actors allocating resources and ongoing activities is established over time, consistent with the development journey of buyer-seller relationship (Metcalf et al., 1992). Specifically, client provides funding and make requirement about the construction projects, contractor is hired to manage the construction process, which is mostly implemented by numerous small subcontractors. Contractor usually has more power over subcontractor in terms of the scale and access to resources, as defined in atmosphere analysis of industrial network (Axelsson & Easton, 2016).

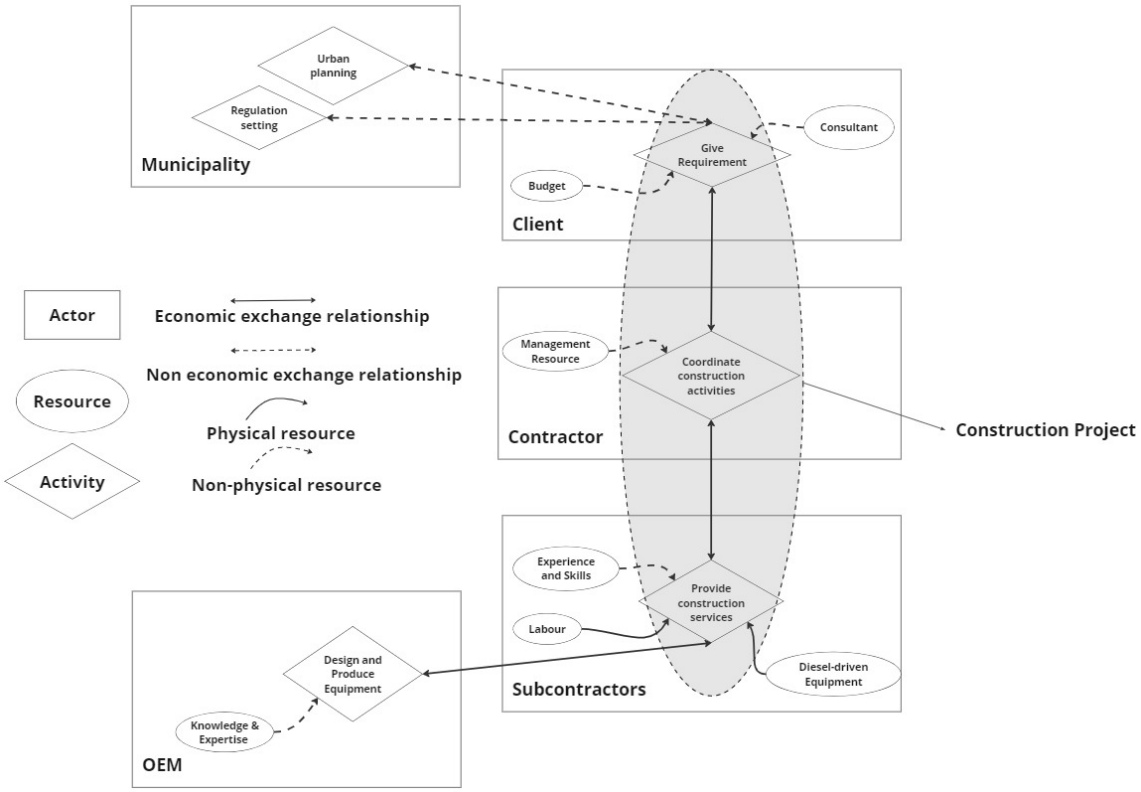

Figure 5.1: The traditional construction business network

Due to the established process of conducting construction projects as well as the power disparity, a hierarchical structure is formed among these actors as illustrated in Figure 5.1. The uncertainty in construction activities further leads to a wide adoption of contracting to respond in time and new ways of building but at project level (Bygballe et al., 2014). Such way of addressing challenges surfacing during construction process has strengthened the vertical interaction between these actors, which appears more of the transaction and arm-length relationship as explained in the part of INA theories (Håkansson & Johanson, 1992). According to our empirical finding, contractors tend to just hire new subcontractors if there is anything missing along the construction process. Other actors like government and OEM mainly impact the construction projects indirectly via regulation and the supply of construction equipment. To clarify, public parties can have more impact by giving requirements in public procurement, which is categorized into the actor client here.

However, the vertical structure may appear not enough in terms of promoting electrification, since the potential of actors tend to be confined to completing activities in diesel-driven construction project. As pointed out in INA theories, such efficient way of securing resource and activities tends to slow down the progress of obtaining new resource and activities (Axelsson & Easton, 2016). The temporary project environment as illustrated in Figure 5.1 is also not supportive for developing and standardizing innovative solution. The extant actors are taking cautious steps toward electrification. And there is also a tendency to justify the delay of the progress, since the downstream actors have a reason to wait for the actions of the upstream actors like requirements and procurement. As a result, the Swedish construction

industry is still dominated by diesel-driven machines, new resources and activities due to electrification have not been integrated yet.

5.1.2 Collaborative Business Network

The perspective that considers network members as passive entities that solely react to incentives and constraints stemming from their network connections is limited(Dhanaraj & Parkhe, 2006). The potential of actors can be further unleashed once they view themselves as a proactive player instead of just following the established ways and structures. It will switch their mindset from "who should do more" to concretely "what is needed to electrify construction projects". In this case, the role of current actors and new actors can be both explored to promote electrification (5.2). New business relationship can be established among these actors to provide a new combination of resources and activities for electrifying Swedish construction industry. This is aligned with what Municipality A are trying to do: a group of actors are gathered to test various electric equipment and explore new business models.

Summarized from empirical finding, there are four main groups of resources needed: knowledge and skills, electric equipment, charging infrastructure and electricity supply. The extant actors and new actors can work together to fill in the gap by developing new business solutions. In this perspective, the actors are viewed equally in terms of their contribution to electrify construction projects. Main business network for conducting construction project is still kept but not necessarily constrain the role of client, subcontractor, contractor, instead they can support the need of electrifying construction projects. In fact, these actors can always do extra only if they have resources to be capable of some activities. Such horizontal perspective of each actor can infuse potential into developing new business network. As Figure 5.2 presents, compared with a established way of providing activities and resources, based on needed activities and resources, extant actors can adjust their role and new actors can also join the network. This collaborative network is a concept established based on INA perspective (Axelsson & Easton, 2016), guiding our analysis afterwards.

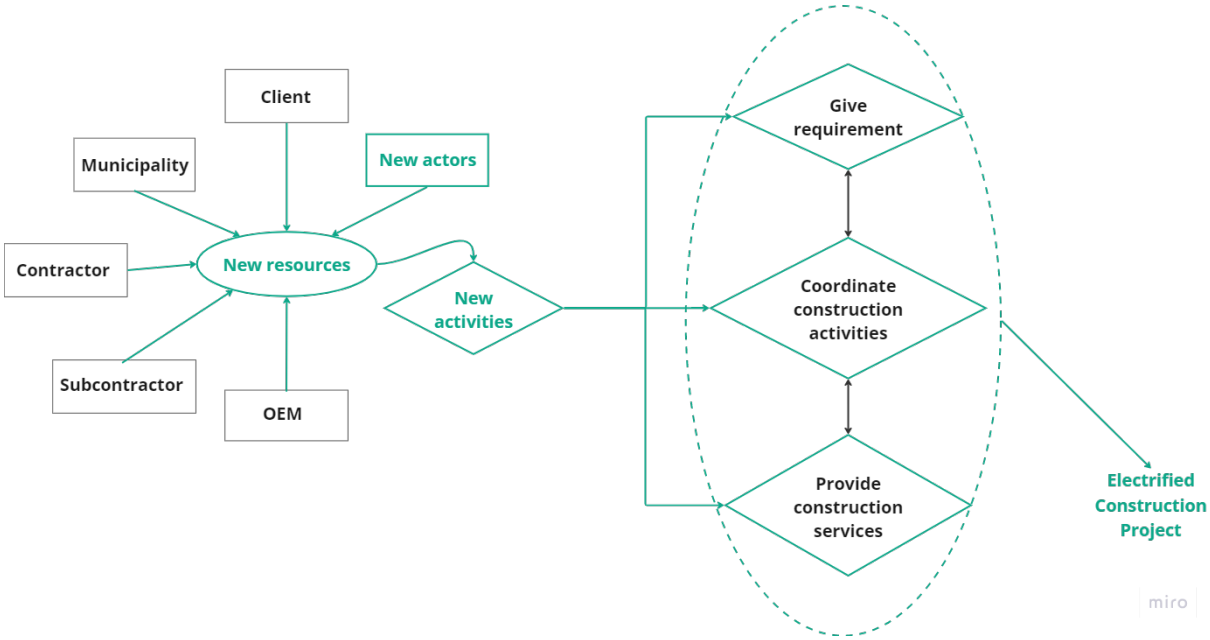

Figure 5.2: A concept of collaborative network toward the electrification

5.2 Identification of Challenges and Opportunities

From the empirical findings, it can be identified that the challenges of electrification mainly comes from inherent feature of construction industry and emerging demands. As compiled into table 5.1, the barriers are classified into three perspectives: feature of construction industry, electrical construction equipment, electricity supply charging logistics, which is inspired by the categorization in the study (Wiik et al., 2021), and is also consistent with the discussion of potential business network above. In addition, potential solutions and activities for each challenge have also been summarized, alongside with the assigned business actors based on their owned resources within the industry. Notably, the proposed actors in the table can be understood as the one who can provide the needed resources for an individual activity, paving the way for the proposal of networked business model and collaborative network discussed later. And resources are embedded in proposed solution so for this item no exclusive column is used.

5.2.1 Feature of Construction Industry

As mentioned earlier, the current construction business network suffers from a lack of networking. The market-based, short-term interactions between independent businesses lead to inadequate collaboration and hinder the sharing of knowledge (Holmen et al., 2005; Bresnen & Marshall, 2000; Gann, 1996). Additionally, this setup tends to prioritize cost-driven relationships, which can potentially become adversarial. Ultimately, these factors impede innovation and pose obstacles to the further progress of electrification in the industry. Electrification is a complex innovation that requires a systematic approach to emerging knowledge and collaborative innovation in order

to drive its development.

The operation of electric equipment needs to consider some conditions specific to a construction site. A construction site is a temporary work environment mostly exposed outdoors whatever the weather condition. The fragmentation of construction activities is also pointed out by several interviewees that a intermittent and unsaturated usage of construction machine is really common. From a more broad perspective, there is a lack of policy support in electrification as well as the lack of actions among construction companies. These features collectively present potential of adopting mobile charging infrastructure and sharing economy, which requires active involvement of new actors charging infrastructure provider, OEM, main contractor and subcontractors. Municipality could support the solution by speeding up relevant policies to motivate these involved actors.

5.2.2 Electrical Construction Machinery and Vehicles

The challenges of adopting construction electric equipment could be identified from the following aspects: the property of the electric equipment itself, the behaviour changes of drivers to operate the new equipment and lastly the market situation of electric equipment. Electric truck and heavy machine have a shorter running range than diesel one, prone to interrupting the process of construction activities as well as the transportation and disposal of construction materials. Hence a planned solution to manage charging should be in position, like setting up charging infrastructure at logistic center and adjusting work routines. Although electric equipment is claimed to be almost identical to the diesel one, it takes time for labours or drivers to accept the difference like cable-connected charging and electricity usage. The arrangement of training and knowledge sharing could help reduce the bumps during the transition. According to the slow process of market, mandatory regulation can be made to improve the awareness, and at the same time large public construction project can be commenced to encourage the development and adoption of electric equipment. The increasing demands of market is expected to be followed by an decreasing cost of investing in electric equipment. In terms of the high initial cost of electric equipment, rental company is believed to be feasible solution and it is not a new concept for construction industry.

5.2.3 Electricity Supply & Charging Logistics

Another concerning aspect is the capacity of electricity grid, the increasing use of electric equipment might cause a temporary but intensive demand of electricity in the region. However, the adjustment of grid capacity should be planned earlier otherwise charging times will be extended. Given that electricity is supplied enough, the choice of supply channel like the installment of charging infrastructure on site is not a favourable investment, since construction project only lasts for a certain period time. So mobile charging solutions and battery powered equipment might be more suitable for construction projects. These issues of supplying electricity requires early involvement of energy agency and charging supplier in construction

project along with the coordination of main contractor. Limited by the technology development, the use of some heavy electric machines need to be connected with cable while operating on construction site. The standardization of cables might take some management resources if lots of cables occupy the working space.

	Barriers and challenges	Possibilities and Activities	Proposed Business Actors
Feature of construction industry	Congested construction site, Temporary work environment, Fragile to weather condition	Mobility charging infrastructure	Charging infrastructure provider(new)
	Unsaturated usage	Sharing economy	Subcontractors, OEM
	Lack of policy support	Regulations and policies speed	Regulator
	Lack of construction companies's actions	Construction companies actively involvement	Main contractors, Manipality
		Subcontractor management	Main contractors
Electrical construction machinery and vehicles	Long distances to disposal sites outside	Logistic centre with charging infrastructure	New supplier
	Few available electric machinery and vehicles in the market	OEMs involved to develop from demand	OEMs
	Heavy electric vehicles have a shorter range – they do not always have enough energy or available electricity to last a full working day.	Adapt work routines, better charging solutions (e.g., rapid charging) and ensure enough electricity supply on the construction site.	Main contractors
		Charging management	Main contractors
	Few demands on market	mandatory regulation to force electrification (municipality)	Municipality, Regulator
		large public construction project to boost electrification	Municipality
	Competition for projects is decided according to offers on the machine fleet.	Pilot projects	Municipality
	High initial cost of electric equipment	Incentives	Regulator
		Electric equipment rental companies	OEM, rental companies(New)
		Public rental companies	Public
	Lack of experience and knowledge from labour	Training and knowledge sharing	Main contractors, organisations(new)
Electricity supply & Charging logistics	Complex process for arranging temporary electricity supplies, especially 400 V – this may lead to delays.	Involve power grid operators in early planning	Main contractors, power grid operators
	Charging problems – limitations of the supply grid may lead to increased charging times.	Involve power grid supplier in early planning	Main contractors, power grid supplier
		Arrange the energy generation ahead in the building project	Main contractors,
		Construction Logistic Center (CLS) for transporters	Main contractors, Logistic
	Short-term demand for Charging infrastructure	Battery powered machines or movable charging infrastructure	New supplier
	Use of cable/battery-powered construction machinery can present challenges related to building logistics	Cable management	Main contractors, new supplier
	There may be several different charging systems for different equipment	Charging management	Main contractors,new supplier

Table 5.1: The challenges and opportunities of electrifying Swedish construction industry

5.3 Networked Business Model

Instructed by the development framework of networked business model (Palo & Tähtinen, 2011), the research so far is positioned at service development phases. As the starting point, this phase is to explore different technology and services, where research institutions form strong cooperative relationship with business actors (Palo & Tähtinen, 2013). Drawing upon the empirical finding, it can be known that the current progress in electrifying Swedish construction industry is consistent with the description of the stage: the role of actors and business opportunities toward the electrification are both presenting a high level of uncertainty, opening for a flexible and innovative combination of resources and activities (Axelsson & Easton, 2016).

Furthermore, integrated solution is considered beneficial for pushing the electrification in the construction industry. This type of solution complies with the business custom of conducting construction projects, which integrates all kinds of services, like the provision of hourly construction activities covering the use of machinery and pilot's operation. So could we nudge the industry to adopt more electric equipment without pushing the incumbents too much? That's where integrated business solutions could come into. It is in line with the insight that new services can be developed more efficiently by embracing existing systems (Rajakallio et al., 2017). Also, from the perspective of value ecology (Hearn & Pace, 2006), the use of the integrated solution could help utilize total innovation resources better on electrifying Swedish construction industry.

Above all, the networked business model here is primarily defined as: with the aim of promoting electrification, resources and activities are combined by a net of actors to provide integrated solution or a system of activities. It is built on the common focus of value creation in business model (Pekuri et al., 2013b), but differently an INA perspective is also integrated to inform the starting point for our analysis, which is missing in most of definition of BM (Buser & Carlsson, 2015). This network business model aims to foster collaboration among diverse organizations and stakeholders, with the goal of generating mutual benefits and co-creating value for all parties involved (Ind et al., 2013). By actively engaging and working together, these stakeholders can leverage their collective expertise and resources to drive innovation, create synergies, and achieve shared objectives. Through this collaborative approach, the network can facilitate the exchange of knowledge, ideas, and best practices, leading to the generation of value that positively impacts all stakeholders in the network. The definition also absorbs the argument of not viewing business models in the project based industry either at project level or firm level (Pekuri et al., 2013a). Instead, analysis should be done at the level of individual solutions (ibid.), which can be later hired in either temporary project environment or integrated as part of firms' operation.

Considering the feature of construction industry and what are fundamentally lacking under the electrification, three integrated solutions are proposed. As illustrated

in Figure 5.3, four types of actors are identified as important roles forming the solution providers to collaborate and co-create the value for promoting the electrification project. Construction company refers to traditional actors like contractor and subcontractor. Public agency includes public client and policy maker. OEM is responsible for the design and manufacturing activities of construction equipment. Other supplier entails those specialist companies and organisations satisfying new demands due to electrification in construction industry. Solution providers leverage the resources and support from the four key actors to deliver integrated solutions on pilot projects, electric equipment, electrical supplying and charging infrastructure. This role opens for the co-creators or new actors, inspired by the emphasis of an entrepreneurial role to push forward the service development (Palo & Tähtinen, 2013). These solutions aim to promote more electrified construction projects by creating value, including establishing collaboration networks and knowledge banks, reducing the cost of adopting electric equipment, and ensuring efficient electricity supply.

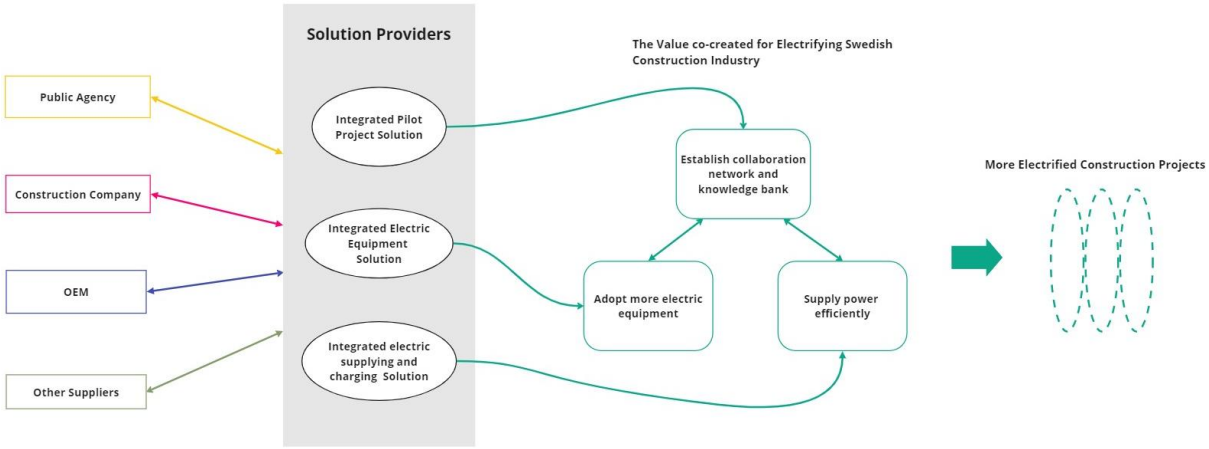

Figure 5.3: Networked Business Models for Promoting Electrification in Swedish Construction Industry

5.3.1 Integrated Pilot Project Solution

Given the effectiveness of pilot project in promoting complex innovation (Frederiksen & Davies, 2008; de Melo et al., 2021), the diffuse of electrification in Swedish construction industry is in the need of more pilot projects considering project variance, technical complexity as well as regional demand and supply. The empirical finding shows that the transition and efforts are both at their early stage. Fundamentally, a well rounded fleet of electric equipment needs to be tested in addition to their charging management (including cable management). In a long run, the setting up of electricity grid should be handled in both rural area and urban area with expected increasing usage of electric equipment. The local distribution of construction project might trigger another concern as project manager LCC2 holds, that will it present as a green washing behavior if electric equipment is transported to work in construction projects at different regions. There are possibilities that the carbon emission due to especially long distance transportation might undermine the environmental benefit of using electric equipment.

Lots of questions are left unanswered, according to the empirical findings there is motivation in learning the electrification then making relevant decisions. Municipality A is investigating the market situation of electric equipment in order to make approachable requirement for construction companies. OEM A is also testing their electric equipment in ongoing construction worksite hereby modifying the design. Construction companies A and B are self organizing R&D projects to test available technical options. Especially in Construction companies A, staff are employed full time to integrate knowledge and experience gained from internal projects. Informed by Project Manager IC1, energy agency is interested to investigate the disruption in electricity grid. Public Innovation Agency A is also expecting more involvement of construction companies in their strategy conversation. The high demand of pilot projects and knowledge about electrification are presenting much business potential.

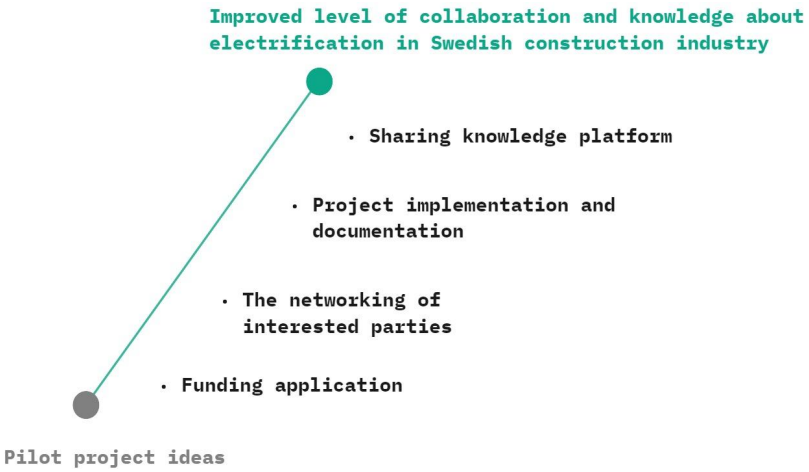

Figure 5.4: Integrated Pilot Project Solution

In order to improve the level of collaboration and knowledge on the electrification in Swedish construction industry, an integrated pilot project solution is proposed here covering four services as illustrated in Figure 5.4. It is considered favorable to have a service facilitating the electrification participants obtaining funding for their pilot projects and tests. Specifically two activities can be covered: informing eligible funding opportunities and guiding the administration process of funding application. The emphasis on the service considers two informed situation: one comes from Vice President Innovation LCC1, there is a lack of resources in small and medium construction company to go through the administration process of funding. Another is from Director of Innovation Department PIA1, construction stakeholders including those big companies are also missing the funding opportunities. The key resources involved would be experts equipped with extensive experience and knowledge in funding application of pilot projects. The applicants might also ask for input from the experts to adjust their aim and implementation of pilot projects. In this case, the experts are expected to be well educated about innovation strategy as well. By working closely with the initiators for electrifying Swedish construction industry, these experts could help provide diverse perspectives especially of construction companies by participating in strategy conversation with innovation funding agencies.

The networking of construction stakeholders is also essential prior to the implementation of pilot projects. The key resources backing up the service could be a stable collaboration network of Swedish construction industry. Technically, construction pilot project requires a real project environment to test the object including various electric equipment and charging solution. In order to connect actors with common goal to co-create and share a project learning environment, a collaboration network and corresponding management need to be at the position. Organisations like Electrification Collaboration Network A and Innovation Center A indeed running on a network base of partners, but notably none of them are established or exclusive for construction industry. When it comes to some construction pilots projects like electric worksite, these organisations also need to reach out actors from the construction industry. Hence the service of networking could facilitate the participation of extant actors in exploring electrification and also involve new participants. As informed by Project Manager LCC4 and Site manager LCC5, OEM A can test their electric equipment directly in ongoing construction projects because of their established relationship with Construction Company B.

The implementation and documentation of pilot projects could also be delivered as a service considering its complexity. The execution of pilot project asks the similar resources as conducting a construction project. Participants bring their resources onsite and go through the assigned work packages, and a management role might be needed to drive the overall flow of the project. After the completion of project, the work of compiling the experience and learning from these projects can be undertook by a certain actors. It is in contrast to the current situation that every partner learns something and leaves once the pilot project finishes (mentioned by Innovation strategist electrified transport M1). Furthermore, the empirical findings from those pilot projects can serve as an major input in establishing a sharing knowledge bank or platform. Some knowledge can be updated timely like the availability of electric equipment in the market, the application of different charging solutions and their performance, the interruption in electricity grid and electricity safety. In addition to the project participants, other actors across municipalities could also join the collaboration network and then have access to the platform. This concept is similar to what Construction Company A is working on, but differently, this platform is expected to take effect across organisations and even regions.

The solution above can be delivered efficiently by combing resources and activities from different actors. Public actors like Municipality A, some leading OEM and Swedish construction companies can utilize their buying power to initiate a collaboration network for electrifying construction industry. A high level of feasibility can be perceived if looking at the roadmap for fossil-free competitiveness in the Swedish construction and civil engineering sector (Federation, 2018), which is under both government initiative and large companies' leadership. In terms of implementing and documenting pilot projects, construction companies are totally capable of providing the essential management resources as involved in their core business activities. Other suppliers specialising in funding application and sharing knowledge platform establishment are also required, where research institution could play an important

role. A solution provider can organize and integrate all these resources and activities to present a enhanced service. In fact, the extant organizations like Electrification Collaboration Network A, Innovation Center A and Regulation Association A have the tendency to be the provider considering their aligned business operation, apart from their current operation that a group of actors are just temporarily gathered for a pilot project.

As the co-creators of the solution, these actors above not only contribute to but also benefit from a constantly strengthening collaboration network and knowledge platform. Swedish municipalities can understand the market situation in a more efficient way. The free access to the network and knowledge will facilitate their new procurement requirement for electrification in the construction sector. Construction companies can also obtain more funding to explore sustainable solutions for electrification and find commercial value, which is considered as an effective way to promote the trend by Vice President Innovation LCC1 from Construction Company A. By co-creating the solution, construction companies could also gradually develop their experience and skills in project portfolio management, which will have an positive impact on their core business by forming a strategic partnership business model (Berg et al., 2021b). As one of the co-creators, OEM can make a full use of the pilot project environment to test their products and gain more competitiveness.

Notably, the wide adoption of electrification in Swedish construction sector is a time consuming process considering the complexity of regional feature, project environment and involved companies. The pilot project solution proposed here is expected to produce an initial momentum of exploration for interested parties at different levels. It is consistent with some initiatives like electric worksite administrated by Innovation Center A . But differently, the created pilot project learning environment is considered to be utilized for establishing a collaboration network and knowledge sharing platform among Swedish construction industry, which instead can facilitate the creation of project learning environment in the future. But this seems to be missing in the current conduction of relevant pilot projects. So the solution can help improve the situation by tuning the current way of working, and also considering what comes next after the completion of pilot projects. As the demand of new knowledge about the electrification decreases, the development of the solution can still pave way for new business opportunities, like providing education and training for actors working with the electrification (when a high level of knowledge is achieved on the platform). Other than electrification, the solution can even be extended to a specific hub of construction pilot projects and tests covering more innovation and sustainability research in Swedish construction industry. This again will benefit all the co-creators since they can always be informed about the updated technology, knowledge and new business opportunities.

5.3.2 Integrated Electric Equipment Solution

As discussed, the Swedish subcontractors in the transport sector primarily consist of numerous small haulers. Even larger logistic companies such as GLC are essentially

an amalgamation of small holders. These companies are responsible for purchasing and owning the machinery and vehicles required for project operations. However, this poses a challenge when it comes to investing in electric vehicles, as the upfront cost of electric machinery is 1.5-2 times higher than that of traditional machinery. Additionally, the need for charging infrastructure further complicates the investment decision. Researcher RI1 and RI4 have highlighted these financial considerations. The younger operators and smaller companies are particularly susceptible to the financial risks associated with transitioning to electric machinery, as they may not have a long history of generating surplus funds, making it difficult for them to secure loans from banks. Medium to large-sized companies may also face challenges in adopting electric machinery. To bridge this gap and mitigate investment risks, the introduction of integrated electric equipment solution is suggested.

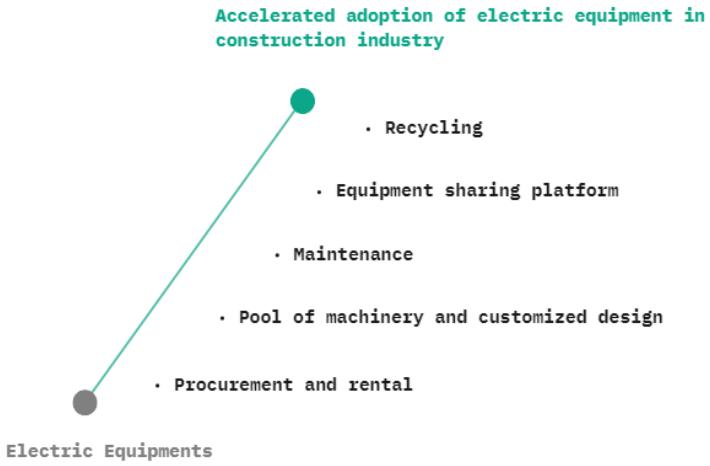

Figure 5.5: Integrated Electric Equipment Solution

An integrated electric equipment solution, depicted in Figure 5.5, provides five comprehensive services that procure various types of electric machinery and vehicles from OEMs and offer them to subcontractors on a rental basis, addressing their potential needs for electric equipment in fossil-free projects or any other relevant projects. With the ability to serve multiple construction projects across different regions of Sweden, it addresses the limitations faced by local subcontractors in meeting demands beyond their business scope. This is particularly beneficial in the early stages of electrified construction projects, where the demand for electric equipment may not justify individual ownership in a specific area. By offering nationwide services, the solution bridges this gap and ensures efficient access to electric equipment.

This integrated solution offers procurement and rental services for the electrification market, providing a diverse range of electrical equipment to support construction sites as its key resources. Renting specialized machinery for specific operations in construction projects proves to be a suitable alternative to purchasing. Additionally, the solution's substantial pool of machinery enables it to negotiate lower equipment prices with OEMs, presenting a more advantageous option for individual subcontractors.

Furthermore, leveraging its extensive equipment resources, the solution can establish a machinery pool consisting of a wide range of electric equipment and vehicles to meet the diverse needs of different projects. In construction, there are situations where specialized machinery and equipment are only required for a limited duration, making rentals an ideal solution. Additionally, utilizing its abundant equipment inventory and equipment management capabilities, this solution can offer tailored equipment designs to fulfill specific requirements, ensuring precise and customized service delivery.

Maintenance and repair are crucial aspects of construction projects, ensuring timely operations and prolonging the lifespan of machinery. Regardless of the type of machine used, regular visits to workshops are necessary. While electric equipment generally requires less maintenance and repair compared to fossil fuel-powered equipment, it still requires specialized maintenance services and expertise in electric power systems, which may not be readily available through traditional maintenance suppliers. A comprehensive solution that takes full responsibility for equipment and provides fast response and expertise can be invaluable for construction sites. The key resources in this context are the knowledge of equipment and the relationships with equipment providers. By offering its own dedicated repairing and maintenance services, the solution can establish a competitive advantage, providing efficient support and ensuring optimal performance of the machinery.

In the construction industry, equipment idle time is a common challenge that cannot be completely avoided, even with meticulous planning. However, the solution can address this issue by leveraging its extensive pool of machinery and project management expertise to establish a sharing platform for electrical equipment. This platform enables the sharing of investment costs among multiple projects in close proximity, allowing them to utilize the same equipment during construction. Effective planning plays a critical role in maximizing the utilization of these vehicles, and the solution must prioritize and enhance this aspect of its business to ensure optimal efficiency and resource allocation.

Furthermore, the solution can make a valuable contribution to addressing the challenge of battery recycling, which is a significant concern in the context of electrification (Gaines, 2014). By establishing an integrated and standardized process for the disposal of batteries at the end of their life cycle, the solution can actively minimize environmental impacts. The key resources required to achieve this include in-depth knowledge of battery technology and electrical equipment, as well as strong capabilities in equipment management and planning. By effectively managing the recycling and disposal of batteries, the solution can ensure the responsible and sustainable handling of these components, thereby promoting a more environmentally friendly approach to electrification in the construction industry.

The solution addresses several challenges in the context of electrification within the Swedish subcontractor landscape. In terms of potential options for the solution

provider, key actors could include OEMs, the public sector, and construction companies. Collaboration with OEMs can enhance equipment affordability and access through negotiation and customized design options. Involvement of the public sector, particularly through the establishment of a publicly-involved rental company, can provide support and resources for widespread adoption of electric machinery.

One potential business model involves the establishment of a publicly-involved solution provider, similar to the equipment pool initiative implemented in Sweden during the early 1950s, where the government supported industrialization by supplying a fleet of machines. This type of business can be introduced to support the electrification as well.

Another opportunity lies in the involvement of OEMs in the solution provider business. OEMs possess a significant advantage as they are the producers of the equipment. They have the necessary resources, including equipment and maintenance supply, to effectively operate in this domain. Moreover, the service industry generally yields higher revenue than traditional manufacturing. Similar to the private car industry, where car manufacturers have already ventured into the rental and sharing sector to optimize product utilization and increase profits, some OEMs (as mentioned by Director of innovation department PIA1) have initiated rental services, albeit without considering it as a holistic product service.

The integrated solution brings significant value to four types of actors in the construction industry. Firstly, small subcontractors benefit by avoiding financial risks while seizing business opportunities, enabling them to embrace electrification without disrupting their traditional construction practices. OEMs, as co-creators of the solution, gain advantages through collaboration with the solution provider. They can jointly upgrade the design of electric machinery based on user experience and data, leveraging valuable insights to enhance their products and compete effectively in the evolving market. The solution provider's diverse range of equipment caters to the specific needs of different projects, benefiting both municipalities and construction companies. By reducing risks and costs associated with electric equipment, the solution accelerates the adoption of electrification in the construction industry, leading to improved utilization and overall performance.

In terms of promoting electrification, the solution provider plays a crucial role with engaging relevant actors such as OEMs and the public sector. This active involvement drives the adoption of electric machinery and supports the transition to an electric construction industry. The rapid pace of technology integration poses a challenge for electrical equipment, making collaboration with OEMs and municipalities essential. By working closely with OEMs, the solution provider stays up to date with the latest technological advancements, incorporates improvements into their rental offerings, and ensures that the equipment remains relevant and in demand. Involvement with municipalities is vital as they shape policies and provide support for the adoption of electrical equipment. The solution provider aligns with mu-

nicipal strategies, collaborates effectively, and navigates regulatory requirements to access potential funding or incentives that encourage the use of electrical equipment. While the Norwegian government has taken proactive steps to support electrification, Sweden lacks similar incentives and support, as mentioned by Project manager in procurement RA1. Therefore, the solution provider's role becomes even more critical in driving the adoption of electrification in Sweden.

Looking towards the future, the solution provider has the opportunity to broaden its business scope and extend its services as a subcontractor to construction projects. This expansion would go beyond offering rental equipment and involve actively participating in project execution. By becoming directly involved in the construction process, the solution provider can offer specialized expertise, technical support, and efficient coordination, contributing to the overall success of the project. This enhanced role as a subcontractor allows for a more comprehensive and integrated approach to electrification in construction, further solidifying the solution provider's position as a trusted partner and fostering long-term collaborations with construction companies.

5.3.3 Integrated Power Supply solution

The provision of power supplying and charging infrastructure poses a significant challenge from empirical findings in electrified construction project, where battery-powered and cable-connected equipment relies on a stable source of electricity to operate. The changing locations of construction sites make it impractical to depend solely on existing commercial charging stations and local electric grids. Consequently, the availability of power supply on construction sites has become crucial for future projects.

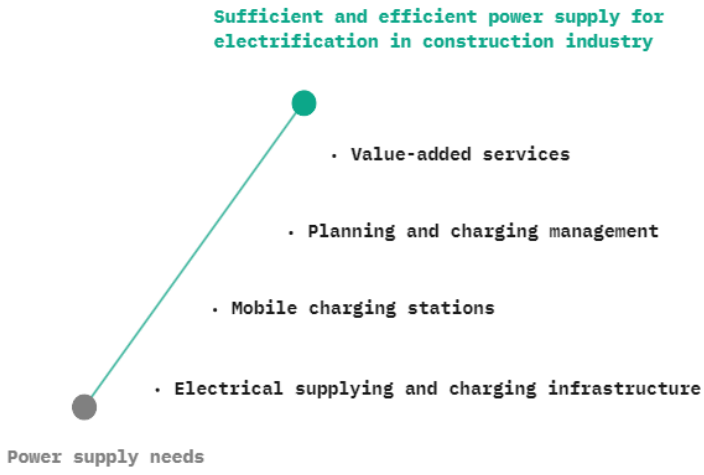

Figure 5.6: Integrated Power Supply Solution

To facilitate the transition from fossil-fueled one to electric equipment, integrated power supply solution should offer comprehensive electrical supplying and charging

services to main contractors as illustrated in Figure 5.6. By acting as a total supplier, this solution can support contractors and builders throughout the electrification process, from initial planning to project completion. The scope of this solution should encompass electrical supplying and charging infrastructure, mobile charging stations, and charging management and value-added services.

Electrical supplying and charging infrastructure is crucial for construction sites with available electric grids. This solution need to provide charging poles capable of meeting the varying equipment demands on the construction site. The nature of the infrastructure can be temporary or permanent, depending on the project's objectives. Temporary solutions could involve plug-and-play charging systems that simplify and cost-effectively facilitate electrification. In contrast, permanent solutions may involve integrating charging infrastructure into the overall construction planning, allowing for reuse as part of the project or commercial use.

In situations where no available electric grid exists on the construction site, mobile charging stations can be provided. Examples of mobile charging solutions include Norway mobile charging provider Aneo, which offers a battery storage system with a power supply and an integrated building power cabinet within a container. This solution enables the normal charging of machinery and other equipment. Another option is a mobile fast charger without a battery, which is suitable for projects with sufficient grid capacity.

To integrate solution effectively, the planning of charging infrastructure should be incorporated early in the construction project. This prioritization ensures that the necessary charging infrastructure is available to support the electric equipment's operation. Alternatively, the charging infrastructure can be added to the construction plan, built in advance, and subsequently repurposed as a commercial charging station. Additionally, this solution can extend their offerings to provide EV charging service for housing associations and apartments, tailoring solutions to meet various charging needs while ensuring stability and reliability.

This solution can also supply value adding services for improving of electrified site. Charging management plays a crucial role in construction projects, involving time management for charging and adapting to various charging plug requirements. Construction companies are benefited by optimised site management from´the integrated solution. Data collection of electricity consumption can be an additional service offered by charging providers. This data provides project managers with cost insights and can also be shared with OEMs for network optimization and collaboration purposes.

The integrated solution's key resources encompass products and knowledge concerning electrical supplying and charging infrastructure, as well as mobile charging solutions. It is essential for the provider to possess a comprehensive understanding of electrical systems, including power supply and charging technologies, in order to

ensure smooth operations and optimize the utilization of electric machinery. Additionally, their implementation ability enables them to efficiently execute plans, deploy equipment, and establish charging infrastructure on construction sites. Effective project and site management, as well as strategic sequencing of power supplying and charging, are crucial ability for the success of the integrated solution. Proper project management ensures efficient equipment deployment and resource allocation, while site management optimizes the placement of charging stations. Sequencing the power supply and charging process minimizes disruptions and maximizes energy utilization.

By implementing mature and supportive electrical supplying and charging solutions, the municipality and construction companies in the Swedish subcontractor sector can overcome the challenges associated with electrification without disrupting traditional construction practices. This approach also benefits OEMs by providing them with valuable user experience and data to enhance their products and competitiveness. The collaboration between solution providers and OEMs deepens, driving further innovation. With accelerated electrification, the barriers related to electrical supply and charging services are effectively addressed. This comprehensive solution opens up new possibilities and encourages construction companies to choose electric equipment, leading to widespread adoption and fostering a more sustainable construction industry.

Looking to the future of this business model, truck manufacturers recognize the business potential of providing charging infrastructure at their sites, as mentioned by Researcher RI1. While the Swedish government has invested in charging infrastructure for private cars, there is a need to expand the focus to include goods transport. Public charging infrastructure is essential for the full transition of construction logistics to electric vehicles. However, the fragmented nature of the trucking industry may result in charging station queues. Construction logistics centers or mass logistics centers could offer charging as a service, although challenges may persist during peak hours. Norway leads in the electrification of construction sites and has gained valuable experience in addressing challenges and finding solutions. Limited grid capacity in places like Oslo emphasizes the need to address charging infrastructure limitations. Norway has introduced subsidies for electric construction vehicles and mobile charging stations with integrated buffer batteries. These subsidies cover up to 40% of investment costs, with specific criteria for battery energy content and charging station power. The success of integrated electrical supplying and charging solutions in Norway could potentially benefit future similar policies in Sweden.

6

Conclusion and Discussion

This part wraps up the research by answering the proposed research questions as well as presenting some discussions.

6.1 What are the features of business network in Swedish construction sector and what is the impact that electrification could bring on the network?

The business network in Swedish construction sector mainly consist of a long lasting but intermittent buy-seller relationship, with client and construction companies (contractor and subcontractor) connected by a vertical transaction chain at firm level. The relationship is characterized with low stability and independence. The structure is highly related with the common way or the sequence of conducting a construction project: make requirement - coordinate construction process - implement construction activities. These activities are combined into a series of site-based operations, project-centric business models, and temporary supply chains. Viewing from the INA perspective, the solidified occupancy and utilisation of a certain resources not only specialise those subcontractors as mentioned frequently in literature, but also the role of client and contractor.

Based on the feature, there exists two kinds of perception when it comes to promoting electrification. One group stands for complying with the structure that each actor sticks to the current role. In this case, the promotion of electrification become rather straight forward, especially for contractor, that it is client who needs to make more requirements and also subcontractor (construction service provider and OEM) who should bring out their electric equipment in the market. Correspondingly, the higher price of electric equipment than the diesel-driven one is considered as the main challenge, and the "solution" is proposed: market always takes some time to be mature. On the contrary, the other group of interviewees believe that, compared with other industry like mining and private car, construction industry is already lagging behind in terms of electrification, and the process will be delayed without

more efforts. Consistent with the awareness, pilot projects driven by municipality like electric worksite are initiated to explore more business potential by involving more actors equally. Although started from a small scale, a continuation of such pilot projects can be expected, at least enabling public actors to make some requirement of electric equipment on Swedish construction site. It is acknowledged by Municipality A that the efforts toward electrifying Swedish construction industry are made but still at a very early stage, leading to an uncertain but also potential future development.

Therefore, there is a range of impact that electrification can impose on Swedish construction industry, from adoption and diffusing a new technology for satisfying environment goal to making extra contribution touching upon some inherent challenges in the industry, including lack of network and motivation in absorbing innovation. While chasing toward the electrification, part of Swedish construction industry may choose to wait for a more mature market. The insistence on adopting a familiar solution, that is to wait and hire more specialised subcontractors to provide electric equipment and relevant services, tends to strengthen the current vertical business network. On the other hand, more exploration about business relationship might inspire a new constellation of business network. The boundaries, formed by the vertical structure of client-contractor-subcontractor, can be broken by different ways of combining resources and activities. The emergence of new demands like setting up electricity grid, supply of electric equipment and charging services is welcoming the arrival of new roles and actors. Some outstanding cases are that supplier OEM can go over subcontractor to work directly with contractor, subcontractor like charging service provider is needed to participate throughout a construction project.

6.2 What are challenges and opportunities in electrifying Swedish construction sector?

In general, the construction industry's inherent characteristics pose challenges for the adoption of electrification, while the introduction of new technologies further complicates the landscape, necessitating the new role of extant ones and involvement of new business actors. Drawing upon empirical findings mostly from interviewed practitioners, lack of collaborative networks and lack of motivation can collectively explain the slow progress of the electrification in the construction industry. Looking more closely at these two aspects, three major groups of challenges can be identified as: feature of construction industry, electric construction equipment, electricity supply and charging logistics. More details could be obtained by reviewing Table 5.1. In the table, potential solutions and activities for each challenge have also been summarized, alongside with the assigned business actors based on their owned resources within the industry. Notably, the proposed actors in the table can be understood as the one who can provide the needed resources for an individual activity. This way of presenting information is to show the business opportunities of extant actors and new actors.

6.3 What forms of networked business models for promoting electrification in the Swedish construction sector can be identified?

Considering the feature of construction industry and what are fundamentally lacking under the electrification, three integrated solutions are proposed. Integrated pilot project solution aims to provide comprehensive services for realizing pilot project ideas from funding application to knowledge management. Starting from focusing on pilot project of electrifying construction industry, this solution also intends to create a long term value including establishing collaborative networks and knowledge sharing platforms in the industry. As the solution develops, it becomes possible to provide education and training for actors working with electrification.

Integrated electric equipment solution, as described, would primarily focus on providing electric machinery and vehicles on a rental basis to subcontractors in the Swedish construction sector. It has the potential to overcome challenges related to electrification including high upfront costs, and limited access to financing and contribute as a facilitator, enabling small subcontractors to access and utilize electric machinery without the financial risks and barriers associated with ownership. A set of activities can be provided: procurement and rental with nationwide lifetime services of maintenance, customized design, sharing platform and etc. This service provider can be a strong accelerator of electric equipment evolution within the collaborative business network.

Integrated power supply solution aims to provide comprehensive solution for power supply and charging infrastructure, mobile charging stations, charging management, and value-added services. By addressing the challenges associated with power supply in electrified construction projects, this solution will benefit all actors inside the collaborative business network as a supplement of current network to provide a smooth adoption of electrification.

Based on owned resources and activities, public agency, construction company, OEM and other suppliers are identified as four potential actors to collaborate and co-create the integrated solutions above. A solution provider is proposed to emphasize the coordination of the provided resources and activities. This role opens for the co-creators or new actors, inspired by the emphasis of an entrepreneurial role to push forward the service development (Palo & Tähtinen, 2013). By co-creating this solution, the total cost of investing in electrification can be shared among the actors (Brax & Jonsson, 2009), considering the challenges lack of motivation and collaboration network. What's more, the integrated solutions are developed based on the existing industrial custom (Rajakallio et al., 2017) that services are integrated into construction projects from many actors. Differently, involved actors can have a long term collaboration with each other at the solution level not project level to promote the electrification even other innovation in the industry.

6.4 The Way Forward

A collaborative business network is considered as the context of developing proposed solutions efficiently, considering that there is a need of flexible combination of resources and activities. However, the nature of the construction industry, with its short-term focus on price, often leads to competition rather than collaboration, which tends to affect the scope of collaboration and innovation. Another concern is that stakeholders within the construction industry tend to be risk-averse, refraining from investing in technologies that have uncertainties. These industry practitioners and stakeholders exhibit a strong preference for the traditional construction approach and are hesitant to adopt innovative solutions unless they are convinced of the substantial added value or utility that accompanies the innovation (Wuni & Shen, 2020). Drawing parallel to the electrification of the private car market and Tesla's open innovation strategy, we can see how collaboration and strategic alliances have accelerated the entire industry. Tesla's approach of actively collaborating and forming partnerships in the electric vehicle sector, along with their Open Innovation Policy, has facilitated knowledge sharing and accelerated innovation (Karamitsios, 2013). By refraining from initiating patent lawsuits against competitors who share in their technology, Tesla promotes collaboration and aims to drive progress in the industry as a whole.

While there may be concerns about trust and reliability in the construction industry, it is essential for firms to collaborate with willing and trustworthy business partners to foster fruitful collaborations (Al-Omoush et al., 2023). Pilot projects like electric worksite are initiated to explore more business potential by involving more actors equally. Although started from a small scale, a continuation of such pilot projects can be expected, at least enabling public actors to make some requirement of electric equipment on Swedish construction site. This is a really good try of collaborative innovation in Swedish construction industry. It is acknowledged that the efforts toward electrifying Swedish construction industry are made but still at a very early stage, leading to an uncertain but also potential future development. As depicted in the framework 2.7, the development of networked business model is an iterative process involving the determination of actors and business opportunities. In this case, pilot projects can even be used to test collaborative innovation and integrated solution proposed here, allowing stakeholders to evaluate their impact and make necessary adjustments before scaling up.

The construction sector has faced criticism for its short-sightedness and profit-driven focus, hindering progress towards sustainability. However, electrification offers a new pathway for sustainability in the industry. It is important to recognize that the value of electrification extends beyond immediate goals and sustainability objectives. Sustainability thinking requires companies to prioritize long-term value in electrification while still reaping short-term benefits. This approach aligns with the core principles of sustainability, ensuring that electrification contributes to lasting positive outcomes. Networked business models are essential for addressing sustainability challenges in the construction industry (Evans et al., 2017). These models provide

opportunities to collaborate and influence partners, surpassing the limitations of traditional hierarchical supply chain models. By integrating the supply chain into longer-term collaborative relationships, companies can share value, manage risks, and increase transparency in their practices. This shift decentralizes power relations and fosters increased interactions among stakeholders, ultimately promoting sustainability and driving positive change.

However, it is crucial to distinguish genuine cooperation from superficial efforts driven by marketing strategies. True collaboration requires shared values, transparent practices, and a commitment to making a meaningful impact on sustainability. By embracing collaboration, transparency, and a long-term perspective, the construction industry can overcome its historical shortcomings and make significant strides towards sustainability through electrification. This transformation will not only benefit individual companies but also contribute to a more sustainable future for the industry as a whole.

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A

Interview Guide

Different sets of questions are used for each interviewee based on their sectors, title and knowledge. But in general, a outline of interview can be summarized, with some interview question presented to show the adaptation for various interviewees.

A.1 The Outline of Interview

A.1.1 Background Research (before the interview)

While drafting interview questions, this work intends to collect more information for brainstorming interview questions to relevant both to the interviewee and our research. The sources of interviewees' professional background include web page, social media, publication as well as some information provided by interviewees in advance

A.1.2 Introduction

After a warming up session including a brief introduction of each other and our research focus, a series of questions are asked to grasp the level of knowledge and experience of the interviewee about electrification in construction industry, covering their current job and previous project experience. The information provided in this part is expected to be open and welcoming for following up questions.

A.1.3 The Implementation of Electrifying Swedish Construction Industry

This part of interview questions aims to specify the relevant practices and actions, in which lot of details are prospected including specific challenges and solutions.

A.1.4 Network Perspective

The focus here is the relationship between different actors, including feature of the relationship, some collaboration and expectation on each other. INA perspective is

applied directly here to ask about the owned resources and on-going activities in responded organisation.

A.1.5 Business Models Development & Suggest

Lastly, interviewees are usually asked by what potential business opportunities could they see in the transition, and what is their advice for developing business models.

A.2 Templates of Interview Questions

A.2.1 Version 1: interview construction companies

Introduction
1. Could you brief introduce your role and responsibility in your organisation?
2. What is your knowledge and understanding of the electrification in construction sector?

The implementation of electrification in construction projects
3. Are there any demands or requirement on electric construction sites in Sweden? What kind of client prefer the electric machines and vehicles?
4. What is the role of your organisation and how is its cooperation with other business actors in the project electric worksite?
5. Which resources and activities that your organisation has provided in the electric worksite or other similar pilot projects?
6. What are the challenges in implementing electrification in the electric worksite or other similar projects?

Business model
7. How does your organisation address electrification strategically? Have you set some targets and how much does electrification contribute to your sustainability goal?
8. Could electrification increase your competitiveness in the current market and business activities? Is it a value-added investment for construction projects?
9.Are you considering developing some new business models and partnerships to implement more electrification?

A.2.2 Version 2: interview public actors

Introduction
1.Could you introduce to us about the EU-project you mentioned?
2.What is the relationship between the project above and those pilot projects like Electric Worksite?
3.After pilot projects like Electric Worksite, what is the next step for the City, will the city keep doing the similar pilot projects, then what is the final goal of electrification?

Network perspective
4.Which actors do you work most with regarding construction projects?
5.Is there any roadmap of electrifying Swedish construction industry?
6.Is there any communication, knowledge sharing and collaboration about the electrification between cities in Sweden?
7.There are various organisations participating in the project Electric Worksite, is there clear responsibility to manage knowledge and experience obtained from the

project?

Challenge and opportunities

8.How was the experience of project management service provided by Lindholmen Science Park?

9.Regarding some identified challenges from the pilot project, what is the next step in terms of solving them?

10.Which opportunities can you see in future electrified construction projects (any demand and supply of services are missing)?

11.Will city of Gothenburg consider some zero emission construction projects like in Oslo and UK to boost electrification?

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