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Resource renewal in heavy business networks: the case of Modvion starting up in the Swedish wind energy context

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Abstract
Purpose – Taking the perspective of a start-up company, the purpose of this paper is to analyse resource renewal in heavy business networks.
Design/methodology/approach – The theoretical framework is based on the Industrial Network Approach and, especially, the resource interaction framework, business network settings and studies of starting up in business networks. The basis for the paper is a case study of a start-up in the Swedish wind energy context.
Findings – Resource renewal in this case means replacing one resource, having implications for the resource interfaces in the three business network settings.
Research limitations/implications – The paper contributes to the area of studies of starting up in business networks by identifying a distinct form of resource renewal in heavy business networks enabled by development of resource interfaces in three business network settings.
Practical implications – Managers in start-ups as well as established firms need to interact to create and develop the resource interfaces that are needed to achieve resource renewal. Resource renewal not only is in the hands of start-ups but also requires interactive resource development with various collaboration partners.
Originality/value – This study takes a start-up's perspective to resource renewal of heavy business networks and analyses heaviness based on resource interfaces in three business network settings.

Keywords Start-ups, Energy, Resources, Renewal, Business networks, Wind power

Paper type Research paper

1. Introduction

In recent years, resource development in interaction has been the focus of a number of empirical studies (Håkansson and Waluszewski, 2002a; Baraldi *et al.*, 2012; Håkansson and Ingemansson, 2013) and conceptual developments (Prenkert *et al.*, 2019; Bocconcelli *et al.*, 2020). A resource is an element with potential or known use in relation to other elements (Holmen, 2001). Hence, the value of a resource is determined by how it is combined with other resources both within and across firm boundaries (Håkansson and Snehota, 1995). By combining resources new knowledge of how to use a specific resource can be gained (Gadde *et al.*, 2010). Håkansson and Waluszewski (2002a) argue that heaviness and variety in business networks are crucial for understanding the conditions for innovation. They refer heaviness as to how substantial resource investments and adaptations are, while variety refers to the multitude of different resources and how they are or can be used together. In addition, Håkansson and Waluszewski (2002a) claim that business networks always contain heaviness and variety but depending on the type of resources, adaptations and their history, business networks may be more or less heavy.

The energy system in Sweden can be understood as heavy based on it having companies with long histories of interaction (Kaijser, 1994; Fridlund, 1999). Specifically, it is built on a resource structure containing several sub-structures such as power plants and grid systems. One example is the resource interaction between Vattenfall and the company formerly known as ASEA (today ABB), through which the aim was to develop the first 380 kW power line in Sweden, between Harsprånget hydropower station and Hallsberg, during the 1950s (Kaijser, 1994). This is an example of a sub-structure that is still used today and subject for new development in terms of connecting new resources such as renewable energy sources including wind power. Another example is the collaboration between Vattenfall, E.ON and Svenska Kraftnät to find common solutions to the problem of balancing increasing user demand for electricity with an undersized grid system (E.ON, 2018).

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Studies of innovation in industrial networks emphasise resource development as an interactive process (Håkansson and Waluszewski, 2002a; Baraldi *et al.*, 2012; Håkansson and Ingemansson, 2013). However, new initiatives in industrial networks result in confrontations with existing resources and resource interfaces, interaction patterns and economy based on the logics of the involved parties (Bengtson and Håkansson, 2007), which give rise to challenges. In addition, studies show how start-ups as new actors may bring new resources to business networks (Aaboen *et al.*, 2017). Start-ups face an uncertain future with limited resources and no established customer relationships (Aaboen *et al.*, 2011). On the other hand, studies emphasise that start-up companies expand based on initial relationships and their resources are developed in interplay with established networks (Baraldi *et al.*, 2011; La Rocca *et al.*, 2013).

Taking the perspective of start-up companies, the aim of this paper is to analyse resource renewal in heavy business networks. Renewal in this paper assumes existing networks as the point of departure to be renewed in some dimension(s). Renewal is closely linked to development and innovation (Håkansson and Ingemansson, 2013), with an emphasis on replacing existing resources (Aaboen *et al.*, 2016). The aim of this study will be achieved using a case study methodology centred on a start-up in the field of wind power energy in Sweden. The case is used to analyse how a particular resource is renewed in business networks and the role of resource interaction between a start-up and the network in this process. The paper contributes to the emerging area of studies of starting up in business networks (Aaboen *et al.*, 2016; Baraldi *et al.*, 2019; Laari-Salmela *et al.*, 2019; McGrath *et al.*, 2019; Baraldi *et al.*, 2020). It also contributes to identifying a form of resource renewal enabled by resource interfaces in three business network settings (Håkansson and Waluszewski, 2007). The study also provides insights to help start-up managers in industrial networks approaching renewal and innovation in heavy contexts.

The structure of the paper is as follows. First, the theoretical framework of the study is presented with a focus on resource interaction and start-ups in networks. Thereafter, the methodology is described. The case is then described, including an overview of the challenges and possibilities of the wind power industry. This is followed by a case analysis, concluding discussion and implications.

2. Theoretical framework

The paper builds on the Industrial Network Approach to industrial markets, which emphasises networks and interaction between firms in the business landscape (Håkansson *et al.*, 2009). The network model contains three important parts: the actors involved in the business relationships (specifically the companies themselves), the activities performed by the actors and the resources used to perform the activities (Håkansson, 1987; Håkansson and Snehota, 1995).

2.1 Resource development and heaviness in business networks

Resource development has been conceptualised as embedding new resources into three business network settings: developing, producing and using (Håkansson and Waluszewski, 2007). The developing setting includes interaction with collaboration partners during development, for example research institutes and universities. The using setting refers to interactions with users of the resource under development and includes, for example, different types of customers. The producing setting includes interactions with the suppliers of various sub-parts or infrastructure needed to supply the resource.

Based on the established business relationships, resource adaptations and investments made, business networks are characterised as heavy (Håkansson and Waluszewski, 2002a). This means it is difficult to accomplish change in terms of introducing new technologies due to an "already established network of resources and resource interfaces that [have] constructed a specific economy with certain logics and interaction patterns on behalf of involved parties" (Bengtson and Håkansson, 2007, p. 75). Håkansson and Ingemansson (2013) analysed renewal in the construction industry as a process that takes place within business relationships through implementing new ways of working with counterparts or conducting activities; it can also result from new resource combinations. More specifically, Håkansson and Ingemansson (2013) emphasise that renewal needs to be a mutual process in which resources are adapted and developed in relation to other resources, i.e. combined with other actors' resource collections to provide utility. Resource interfaces become visible through the interactions between resources in which their features are adapted in relation to each other.

Resource interfaces have been the topic of several studies. Through studying interfaces, an understanding is gained of how a resource is used at a certain point in time and how this has developed over time (Harrison and Håkansson, 2006). There are different types of resource interfaces: physical or technical resource interfaces (Dubois and Araujo, 2006), organisational resource interfaces (Sundquist and Melander, 2020) and mixed resource interfaces between technical and organisational resources (Harrison and Håkansson, 2006; Jahre *et al.*, 2006). Physical interfaces always require organisations to manage them, and this highlights the importance of mixed interfaces and the special role they play in creating economy from physical resources. According to Bocconcelli *et al.* (2020), the creation, maintenance and change of resource interfaces are underpinned by resource combining.

The heaviness of a business network refers to the strength of a certain resource interface (Bocconcelli *et al.*, 2020). Håkansson and Waluszewski (2018) suggest using three indicators to estimate heaviness in industrial networks:

1. the degree of technological and organisational adaptations between firms;
2. the time required to establish and maintain the business relationship; and
3. the set of relationships that the focal relationship is linked to, such as other actors, resources and activities.

Hence, a high degree of technological and organisational adaptation between firms will make it costly to disconnect combined resources and impact the resource collections of the firms. Additionally, if a change is made in one resource interface it may affect other resources connected across the business network. If there is a high degree of connectedness between business relationships (Anderson *et al.*, 1994), it may result in a heavy system in which combining or re-combining is difficult. Moreover, Håkansson and Waluszewski (2018) stress the differences in the three settings of developing, producing and using in which heaviness is recognised. Hence, new resources may not become embedded into a producing and/or using context due to the heaviness of the business networks. This means that heaviness is not a fixed characteristic of business networks, rather it varies.

Håkansson and Waluszewski (2002b) show that heaviness can occur in, for example, industrial contexts in which many interfaces have been created between physical products with high economic value, such as in the paper pulp industry. The resources in the business network enable the opportunity for a huge number of combinations. This is a result of the *variety* of resources, specifically how many possibilities there are for resource combinations, how heterogeneous they are and how they are combined (Håkansson and Waluszewski, 2002a). Prenkert *et al.* (2019) relate the resource interfaces between two resources to the concepts of heaviness and variety. In greater detail, Prenkert *et al.* (2019) display that the heaviness of resource interfaces could range from light to heavy, while the variety could range from specific to general. This gives room to discuss the multi-dimensional aspects of resource interfaces.

Prenkert *et al.* (2019) also highlight that standardised resources create restrictions for how an interface can develop through adaptation. This kind of interface is considered to have a high degree of variety and thus the resources can be combined with several others. On the other hand, if too many specific adaptations are made in an interface between two resources, the interface can be considered heavy as it may also affect other connected resources and require them to work in a specific way. In the end, the value created from resources depends on the interfaces and the cogency effects (Huemer and Wang, 2021). The cogency effects imply that resources being parts of networks may enhance or destruct value of resources based on their combinations and the interfaces can be matching or mismatching.

2.2 Starting up in heavy business networks

Recently, based on the Industrial Network Approach, studies have focused on starting up in business networks and new resources in the context of newly started companies (start-ups). Studies have focused on start-ups and the development of business relationships with different actors in the business network. One example is incubators, which can provide knowledge and resources such as business and innovation support actors (Shih and Aaboen, 2019). Another example is research institutes that can help in R&D activities (Oukes and von Raesfeld, 2017). Moreover, the importance of creating initial customer relationships has been stressed (Aaboen *et al.*, 2011; La Rocca *et al.*, 2013). Due to the limited resources of start-ups, the investments and focus on an initial customer have a significant impact on the future. For example, specific requests or application areas that require certain competences will lead to a strategy focused towards certain customers, as illustrated by Laage-Hellman *et al.* (2018).

Collaboration with customers can take many different forms and include, for example, pilot tests or joint projects, with the aim of converting these into sales. Many trials and tests are often run before satisfactory results are achieved. Nevertheless, the initial business relationship will have an impact on the further development of the network position (La Rocca *et al.*, 2013). Describing the change of focus for start-ups, Aaboen *et al.* (2013) highlight that the network strategy has evolved from what to sell to whom to sell to and how to build a network position. Other collaboration partners may also be important in this process (Oukes and von Raesfeld, 2016).

Several studies have described start-ups' collaborations with customers and analysed their networking behaviours in relation to the developing and using contexts (Landqvist and Lind, 2019). The development of supplier relationships of start-ups has not been researched to the same extent, as achieving initial sales is typically the top priority. There are some exceptions however; La Rocca *et al.* (2019) focus on the development of supplier relationships and conclude that the initial supplier relationships are just as important as customer relationships for the successful development of a start-up company. From the new venture's perspective, La Rocca and Snehota (2021) show that mobilising suppliers is a relational process that requires interaction. In more detail, La Rocca and Snehota (2021) identify the scope for mobilising suppliers for new ventures. It includes not only cost efficiencies, a key rationale for existing businesses, but also, importantly, mobilising technological and managerial resources. Laage-Hellman *et al.* (2020) show that university spin-offs also may have relationships with various academic research groups, master thesis students and research institutes funded by public financiers

Start-ups can have different roles in business networks. Aaboen *et al.* (2016) identify three roles based on resource interaction. The first is resource mediation: mediating and connecting previously unconnected resources, for example agencies connecting travellers and means of transport. The second is resource re-combining: recombining resources in specific relationships, for example start-ups that develop new materials to be used for specific application areas. The third is resource renewal: replacing resources at the network level, for example analogue technology being replaced by digital technologies – this is the role that requires the biggest changes and is most difficult to accomplish.

In summary, the heaviness of a business network refers to the strength of certain resource interfaces, and this is the basis for referring to heavy business networks. There are three main types of resource interfaces: technical, organisational and mixed. All resource interfaces are underpinned by resource combining (Bocconcelli *et al.*, 2020) in the three settings the resources are being embedded in: developing, producing or using (Håkansson and Waluszewski, 2007). It is in these business network settings that start-ups aspire to find a role (Aaboen *et al.*, 2016). The opportunities to renew business networks are determined by the heaviness of creating, maintaining and changing resource interfaces (Bocconcelli *et al.*, 2020).

3. Research method

This paper is based on a case study methodology (Halinen and Törnroos, 2005) allowing for the study of "a contemporary phenomenon, which is difficult to separate from its context, but necessary to study within it to understand the dynamics involved in the setting" (p. 1286).

The case study should be seen as an interpreted story of the reality and not only as statements of constructs (Dyer and Wilkins, 1991). The strength of single-case research is thus the close relationship to the empirical world, which is not predefined by theoretical frameworks but instead theoretically framed along the way (Andersen *et al.*, 2018). The phenomenon in this study is a start-up aiming to establish itself in and contribute to the renewal of the Swedish energy system, specifically the wind sector. Modvion was chosen as a focal start-up because of its ability to illustrate the attempt of contributing with a new resource into an already established structure.

The case study relies on semi-structured interviews (Bryman and Bell, 2015) with the focal start-up and actors in its network and secondary data. This case description is part of a larger study available in Landqvist (2020). The founder of Modvion was interviewed on the following topics: background to the company, ongoing pilot projects, relationships for commercialising technology, potential customers and suppliers and other collaboration partners, such as the Swedish Wind Power Technology Centre (SWPTC). The reason for addressing these topics were to capture the business network around Modvion and important interfaces between the wood tower and other resources. In addition, we dug deeper into the wind tower by relying on secondary data such as master's thesis reports on topics written on behalf of Modvion, which have been important sources of data for capturing the technical details of the wood tower. To understand the context into which the wood tower will be integrated, journal articles, websites and press releases, example of Modvion, Moelven, Chalmers, government reports and other sources, such as published interviews with researchers on trends in the wind sector, have been key documents. Furthermore, the actor SWPTC played an important role in developing the first prototype of the wood tower. Therefore, the centre coordinator was interviewed regarding the role of the centre in this project, and the collaboration with Modvion. The interviews have been recorded and transcribed.

The case analysis has been a process of matching the empirical description with theory (Dubois and Gadde, 2002), which resulted in the identification of several key concepts that could help in understanding resource renewal in heavy business networks from a start-up perspective. The first step was empirical and regarded to analyse Modvion in its business network (Håkansson and Snehota, 1995) and identify important business relationships ongoing and under development that facilitated the development of the wood tower. In the following step, the business network analysis of Modvion displayed that resource interaction with different actors were of importance to understand how the wood tower could be useful. Consequently, the following step focused on the focal resource (the wood tower) and how it was adapted to fit into the context of wind power. It revealed how Modvion visioned the importance of embedding the resource among the existing resources, including facilities and other organisational units. By asking questions and collecting information from other sources, such as master theses written on behalf of Modvion, about the wood tower and how it was adapted in relation to other resources, it became evident that the adaptation impacted resource interfaces (Dubois and Araujo, 2006) stretching across the three business network settings (Håkansson and Waluszewski, 2007). The use of the three business network settings acted as a foundation to structure and analyse the empirical data in combination with the types of resource interfaces identified, see Table 1 for analytical scheme.

The final step was analytical generalisation, which according to Andersen *et al.* (2018) is grounded in empirical observations as well as theory. Here, the characters of the resource interfaces in the using setting and its consequences for the interaction in the developing and producing settings emerged. Also, the resource interaction with suppliers in the producing setting emerged as an aspect explaining this form of resource renewal.

4. Starting up in the wind power industry in Sweden

The case of Modvion starting up in the wind power industry in Sweden is described below.

4.1 The challenges and possibilities of the wind power industry

To bring new renewable-energy technology into the Swedish energy system and enable a shift towards 100% renewable electricity production will require a multitude of adaptations between existing and new infrastructure. Today's grid system is faced with the challenge of adapting to a more unstable supply of electricity provided by solar energy and wind power. Overall, Sweden has a good environment for harnessing wind power due to its large area and wind resources. In 2020, there were 4200 wind turbines installed in Sweden, and approximately 16% of the electricity produced in Sweden comes from wind power according to the Swedish Energy Agency (Berard, 2021). Moreover, the Swedish Energy Agency estimates a need for an additional 80–120 TWh of renewable electricity production to reach a 100% renewable energy system by 2040. With respect to current technical and economic prerequisites and regulations, wind power is the renewable energy source with the greatest potential. One way of achieving this potential is to build taller towers and larger rotors. Rinne *et al.*'s (2018)

Table 1 Analytical scheme for the case analysis

Business network settings:	Business interaction partners	Technical resource interfaces	Organisational resource interfaces	Mixed resource interfaces
Developing setting				
Producing setting				
Using setting				

study, comparing old wind power technology with the wind turbines being built today, shows that the new larger rotors improve power potential significantly. Furthermore, tall towers can be used in areas where there is not much wind, to reach higher and stronger winds. Today, there are wind power towers that can generate five to twelve megawatts, which is a huge increase on those developed during the 1990s, which were only able to produce an amount of electricity in the kilowatt range. As Rinne *et al.* (2018) also emphasise, using large wind turbines means fewer installations and thus less land used.

Many foresee wind power having the potential to increase its share of the world's power supply and contribute to carbon dioxide-free electricity production as a substitute for fossil fuels. A group of international researchers published a call for action to join forces on wind power energy and identified the challenges of wind science research (Veers *et al.*, 2019). These challenges are international, even though the pre-requisites and legislation differ between countries. The first challenge identified by Veers *et al.* (2019) is to increase the understanding of how the physical conditions of wind affect turbines in terms of production capacity and life expectancy. More energy can be used from taller wind turbines, which in the future could reach heights of up to 300 m. Taller towers also mean new wind and air currents, about which new knowledge is needed. In connection to this, there will be new challenges associated with bigger plants, for instance transportation and recycling. The second challenge has to do with structural dynamics in terms of material and construction design, and there is currently a search for new materials that are both light and strong. The third challenge is more technical and focuses on the need to maintain stability in the electricity grid as the proportion of weather-dependent production increases.

Research is currently being conducted at the Chalmers-based Swedish Wind Power Technology Centre (SWPTC) in relation to those challenges. The goal of the centre is to optimise the capacity of wind power plants and make production and operation more cost-effective. The centre builds on collaborations between industry and academia, examples of which are start-up companies. There are currently three start-ups connected to the SWPTC: Modvion, which is focusing on building a large and stackable wind power tower from wood; Seatwirl, which is developing a floating wind turbine for the ocean; and Greenbite, which is providing a digital application to collect data from wind power units. Modvion was identified as a relevant study object based on its innovative business idea and breakthrough in the context of the established energy system.

4.2 Modvion starting up in the wind power industry

Modvion focuses on developing modular wind power towers from composite materials. It started as a project at Chalmers School of Entrepreneurship (CSE) in 2015 when an inventor introduced the idea of building wind power towers from wood to two students. The inventor had previous experience of building boats from wood, and when he saw a 100-m-tall wind turbine built out of wood in Germany, he thought there was good potential to develop the idea further. During their year at CSE, the two students developed a business model around the idea, and in 2016 Modvion became a registered company.

4.2.1 Modvion's business concept

Modvion's business concept is focused around building a wind power tower from wood to form the base for windmills. The wood tower developed by Modvion consists of laminated wood sourced from Nordic fir trees. As wood stores CO_2, it is a much more sustainable building material than, for example, steel or concrete. Unlike today's turbines, which need time before the environmental costs of building them is offset, a wood tower will be carbon neutral from the start. Generally, steel and concrete have been preferred as construction materials due to their composition and the relative ease with which their strength can be calculated.

Wood, on the other hand, is an anisotropic material with different mechanical properties in all directions because of the nature of its cell structure. Additionally, it is often weak where there were previously branches, which makes it hard to calculate its strength accurately. By cutting wood into thin layers and gluing them together, these weak areas are distributed across the material and thus have a negligible impact on its strength. In addition, the development of better computer programs in recent decades has enabled a simpler process for calculating wood structures and thus facilitated the use of glulam beams (glued laminated wood). As well as building with a sustainable material, Modvion aims to build 150-m wind power towers to enable greater power generation. However, large towers are difficult to transport on roads to wind parks. According to Swedish regulations, there is a maximum width for road-driven lorries. A tower with a diameter greater than 4.3 m will result in a load that is too wide to transport. Consequently, Modvion's plan is to offer the towers in stackable parts, allowing them to fit on conventional lorries. Building towers out of wood according to a specific design will decrease the production cost of wind power by 40% according to estimates (Modvion, 2020b).

As explained above, developing large wind power towers has some challenges, for example the increased costs of transporting them. The Swedish Energy Agency also addresses the challenges of the planning stage resulting from long lead times and uncertain licensing procedures. Moreover, the grid system and main lines in many parts of Sweden are already operating at maximum capacity, and the expansion of the lines therefore needs to be coordinated with the geographical expansion of wind power. To meet these challenges, the Swedish Energy Agency invests money in various innovative projects, such as Modvion's development of a wind power tower made from wood. Looking at the value chain of the wind power industry, it consists of a project manager, such as an energy company that both owns and maintains a wind park, or an actor that wants to sell the wind park to the energy companies. The project manager finds a suitable place to establish a wind park and applies for the required licences to build it. Thereafter, the wind turbines are delivered as a package by the turbine suppliers, which in turn have sub-suppliers for parts such as rotors, generators and towers. Modvion enters the value chain as a supplier of wood towers to turbine suppliers, to which the turbine suppliers add rotors and generators.

4.2.2 Developing the first prototype in the West Coast archipelago

In 2017, Modvion received SEK 2 million from the Swedish Energy Agency to develop the modular wind power tower from wood. The project *Timber meets wind power: Tall modular wind turbine towers in bio-based structural material* was the starting point for developing the first prototype of the wood tower (Energimyndigheten, 2018). As the CEO of Modvion expressed: "It is very different experiencing something in real life to seeing it on a PowerPoint slide. This is an important step [for Modvion], and the next step is to build [the towers] on a commercial scale." To build the first prototype of the wood tower, Modvion had to engage several different stakeholders. Specifically, the project consists of the following main partners: Modvion, RISE Research institutes of Sweden, SWPTC at Chalmers University of Technology and Skellefteå Kraft. In addition to the main partners, other companies are involved in developing components for the wood towers, such as the company Moelven, which produces laminated wood products, and the company Pretec, which develops steel components for use in bonds and attachments. In 2017, Modvion received SEK 640,000 from the Swedish Energy Agency to undertake the project *Timber meets wind power: Development of weather protection* to develop weather protection for the wood tower (Energimyndigheten, 2018). The colour and coating companies Teknos and RISE have been involved in developing the coating material. In the beginning of 2019, Modvion also received a further SEK 880,000 from the Swedish Energy Agency to verify its results. All the projects are now in their final stages, and during the summer of 2020 a prototype of a 30-m-tall wind power tower was installed on Björkö in the north-west coast archipelago outside Gothenburg.

During the development process, much focus has been put on calculating the structural design of the wood tower. The top of the turbine consists of heavy equipment such as the nacelle, which includes the equipment used to generate electricity from the wind, the rotor and its blades and the hub that holds the blades. Hence, it is important to use a wood material that can support this weight. To understand which type of wood material and glue to use when considering external factors such as wind and rotor loads, calculations were made both internally at Modvion and externally with collaboration partners. One important partner that helped to conduct tests of the specific components is the research institute RISE. Together with RISE, Modvion analysed the interaction between the wood tower and wind turbine in a computer program to calculate possible resonance. It turned out that there was a problem with the resonance that needed to be fixed. In 2017, a master's thesis student of Applied Mechanics at Chalmers University of Technology identified different loads on the wood tower to study its force flow. Steen (2017) concluded through her calculations that, rather than use Modvion's proposed baseline diameter of 11.5 m and using three Laminated Veener Lumber (LVL) layers in each wood sheet, it would be preferable to use a baseline diameter of 12.5 m and five LVL layers in each sheet to withstand the stress from the wind, rotor, self-weight and tower head. Furthermore, in 2018, two master's thesis students at the Department of Industrial and Material Science at Chalmers University of Technology focused on developing the joints for the wood panels for assembling the future towers at the wind parks. Several requirements for the wood tower were developed and evaluated, such as weather resistance, ease of assembly, ability to handle the rotor force and manufacturability using existing production technologies. Ekblad and Stromblad (2018) concluded that tangential and vertical joining solutions needed to be combined. The tangential joints are used to attach the LVL panels to each other horizontally and the vertical ones to build the height of the wood tower by stacking the modules on top of each other. Moreover, the joints were verified through fatigue tests conducted in one of the machines located at RISE's wood engineering department.

In parallel with developing the components, Modvion held discussions with the glulam company Moelven regarding how to produce the required beams and LVL sheets. Moelven was established in 1899 in the city of Moelven in Norway, initially producing wagon wheels dipped in boiling oil. Today, the company has 3,500 employees worldwide in three divisions: timber, building systems and wood and the production facility in Töreboda that focuses on producing glulam beams (Moelven, 2022a). As part of their master's thesis project, Ekblad and Stromblad (2018) carried out interviews with Moelven to understand how the production of the wood components could be carried out. In their thesis, the students emphasised Moelven's concerns about the required manufacturing tolerances, within which Moelven was not used to operating in its everyday projects.

However, Moelven was eager to continue cooperating with Modvion to develop the parts for the prototype to be built on Björkö. The company saw the value of integrating its material in new types of products and thus changing expectations of the products in which wood can be used. Today, Modvion works in parallel with Moelven's regular production discussing ideas about construction and manufacturing technology, for both the prototype and future automated production. To integrate Modvion in the manufacturing facility, Moelven had to adapt to new requirements and make changes to the manufacturing facility at Moelven in Töreboda. Moelven made room for Modvion's production line alongside regular production and assigned part of its staff to work on Modvion's wood components. Also, Moelven developed specific 3 D models to support the production of the wood parts (Moelven, 2022b). As the tower consists of a mix of different engineered wood products, Moelven uses both its own materials and materials specifically ordered from suppliers at Modvion's request. This required new steps in the existing purchasing process. The production of the prototype has been planned for periods of the year when the facility usually experiences lower rates of production.

4.2.3 Installing the prototype together with the Swedish Wind Power Technology Centre

One important collaboration in the development of the wood tower is with the Swedish Wind Power Technology Centre (SWPTC). The centre was started in 2010 to gather companies and researchers to study the physical aspects of wind power. Until then, research had mostly been carried out on how to develop the grid system to connect it to wind power. Up to now, the centre has worked on 30 different projects related to how to develop the foundation and rotors, among other things, from basic to more applicable and industry-oriented research. A central and important asset of the centre is the wind power pilot on Björkö, to where it was moved from its original location on Hönö. First, new carbon fibre rotor blades were installed that included sensors to measure the load on the blades. Furthermore, sensors were installed in the foundation to measure potential cracks. In the project with Modvion, the plan is to build a prototype wood tower on Björkö to learn more about how well it integrates with the other parts, such as the turbine, foundation and rotors (Wallin, 2020).

SWPTC and Modvion worked separately on different parts of the project to prepare for the installation on Björkö. Modvion mainly focused on developing the wood tower and getting it ready for installation. At the end of 2019, the outer parts were assembled and ready to be treated with the coating solution. However, there were still internal components to be installed. SWPTC focused on laying the new foundation and building a road on Björkö with help from the construction company PEAB. Eventually, when the wood tower was ready to be installed, Modvion and SWPTC took mutual responsibility by being physically present on Björkö. Modvion and SWPTC met once per month to discuss their progress and time frame. The initial plan was to install the wood tower in January 2020, but this was delayed to the summer of 2020. Even before the installation of the wood tower was carried out, Modvion signed two joint declarations of intent with Varbergs Energi and Rabbalshede Kraft. Hence, if the results of the test on Björkö are positive, the plan is to use the experience when building the first 100-m-tall wood tower together with Varbergs Energi. Moreover, Rabbalshede Kraft has showed interest in buying ten wood towers for its new wind power park outside Töreboda (Modvion, 2020a). Consequently, Modvion is planning to build a production line to meet the demand for wood towers. A collaboration project with Vattenfall has also been initiated to evaluate the wood tower for use in land-based wind power parks. The goal of the project is to deliver the wood towers to Vattenfall (Modvion, 2020c).

Beyond the wood products, there is a need to find suitable coating products to protect the wood towers from the weather. The colour and coating company Teknos has played a huge role, together with RISE, in developing a coating solution. The solution is a compact colour that is sprayed directly onto the wood panel making the tower impenetrable and the moisture level on the inside of the tower easier to control. Using a wood material with a constant moisture level makes it easier to manage fatigue loads and reduce the presence of microorganisms than a material with changing moisture levels. To understand which coating solution to use, Modvion, Teknos and Moelven, together with the other collaboration partners, discussed the best coating solution. Teknos has been involved in the product development process from the start and provided knowledge and adjusted its painting system to the wood tower. The coating contains polyurea, which improves mechanical protection and makes the wood tower waterproof (Teknos, 2020). Currently, Modvion is operating its prototype on Björkö and aims to build its first full, commercial-scale glulam wind power tower in 2022.

5. Case analysis

The starting point for the case analysis is resource renewal in terms of the use of a specific resource (wood tower) for a specific application (windmill) in the Swedish wind industry. The case analysis is conducted with the theoretical frame of the three business network settings (Håkansson and Waluszewski, 2007), the heaviness of which in relation to this specific resource is investigated (Håkansson and Waluszewski, 2018) based on different resource interfaces (Dubois and Araujo, 2006; Jahre *et al.*, 2006).

5.1 Resource interfaces in the development of wood towers for windmills

5.1.1 The developing setting

To develop and commercialise a wind power tower made from wood, several business relationships have been developed between Modvion and other actors in the business network across three business network settings. The developing setting refers to the network taking part in the development of the wood tower. Relationships have been developed with developing partners such as the research institute RISE, the research centre SWPTC and the university, based on the master's thesis projects. Examples of start-ups collaborating with academia through research institute projects funded by public research financiers and organised at research centres to set up master's thesis projects can also be seen in other studies of start-ups and their interactions with academia (Laage-Hellman *et al.*, 2020). The developing partners RISE and SWPTC have put great effort into developing the components of the wood tower. In this case, both developing partners have good knowledge of the energy system and have been part of previous research projects related to the wind energy field. When it comes to SWPTC it adapted its facility on Björkö by building a new foundation with integrated sensors to measure potential cracks. Also, it built a new road to facilitate the transportation of the parts.

In the technical resource interface between the wood tower and RISE laboratory, digital simulations in which the wind turbine was installed on the wood tower, showed that there was a problem with potential resonance. Moreover, the mixed interface between the wood tower and academia through the master's thesis students also helped shape the parameters of the wood tower, such as the optimal diameter and number of Laminated Veener Lumber (LVL) layers. The mixed interface revealed that rather than a diameter of 11.5 m, according to Modvion's initial idea, the wood tower's diameter should be changed to 12.5 m and the number of LVL layers increased from three to five. It was also clear in the mixed interface between the wood tower and the master's thesis students that two types of joining solutions would need to be combined to withstand external factors such as weather, loads and wind, as well as to facilitate easy assembly.

5.1.2 The producing setting

In the producing setting, related to the network that needs to be mobilised for the production and transportation of the wood, suppliers play an important role when it comes to the development of the wood tower. In line with La Rocca *et al.* (2019), this has also impacted the development of the start-up company. For example, Modvion collaborated early on with the glulam company Moelven. The company is not a conventional energy company and has no previous experience of similar projects, including producing components for energy-related technology. Hence, the organisational resource interface between Modvion's organisational structure, in terms of creating a sustainable wood tower, and Moelven's knowledge of how to produce wood products revealed a shared idea of using glulam beam material to build large wood towers. As Moelven saw the value in letting Modvion use its production facility, a new technical resource interface was created between it and the wood tower. This was crucial as it enabled Modvion to produce the components developed by the master's thesis students, its employees and RISE. The business relationship with Moelven helped further the understanding of how to develop the production of the wood tower and required adaptations at Moelven's facility. For example, new 3 D models were developed, and a new production line was installed. Hence, new working routines were developed in the mixed resource interface between the production facility and the employees at Moelven. Moreover, the technical interface between Moelven's production facility and that of the wood supplier was important in enabling the production of specific wood products that Moelven was not able to produce. It also revealed adaptations in the existing purchasing process of the wood.

The coating company Teknos also provided its expertise on how to develop a coating material that could withstand hard weather conditions. Moreover, the company adapted its painting system to include polyurea and thus improve the wood tower's mechanical properties.

5.1.3 The using setting

In the using setting, referring to the network involved in the future use of the wood tower, collaborations have been initiated with several actors. Working with potential customers and users can help in guiding which applications to develop for start-ups, as already stressed in previous research (Laage-Hellman *et al.*, 2018). However, Modvion has not been working closely with potential users when it comes to developing the first prototype of the wood tower. Instead, declarations of intent were signed with future users: Varbergs Energi, Rabbalshede Kraft and Vattenfall. The goal has been to provide a functional prototype on Björkö and then use the experience when delivering wood towers to the energy companies.

One important starting point was the organisational interface between Modvion and the wind power industry's organisational structure. It was clear that the general trend within the wind power industry was heading towards taller towers, larger rotors and sustainable materials to generate more electricity with lower production and environmental costs. In addition, the organisational interface between Modvion and the Swedish regulations revealed that the larger towers had to be stackable to meet the regulations on load dimensions. In the mixed interface between the wood tower and the organisational structure of the wind power industry new features of the wood tower was developed in terms of new dimensions such as having a height of 150 m. Also, the mixed interface between the wood tower and the Swedish regulations forced the tower to be produced in stackable parts.

Table 2 shows an overview of the resource interaction in the three business settings and the identified resource interfaces in the case of Modvion.

5.2 Heaviness in relation to renewal of the specific resource in the three business network settings

As can be seen in the previous analysis in Section 5.1 renewal of a specific resource is possible with the help of developing technical, mixed and organisational interfaces. For Modvion, having the aim of starting up in the wind power industry of the Swedish energy system, the way forward was about adapting to what already exists in *the using setting*. Previous studies have stressed the importance of learning from initial customer relationships (Aaboen *et al.*, 2011), but the identified approach at Modvion is another way of interacting with, and learning from, the using setting.

In the case of Modvion, the wood tower was subject to interaction with set standards and trends based on development together with RISE and SWPTC, and the potential users expressed through their declaration of interest the importance of aligning with these industry standard interfaces. Hence, before entering the developing setting it was a matter of meeting set standards in terms of the height of the tower, meaning that when the prototype was built several energy companies were interested in ordering the wood towers, such as Varberg's Energi and Vattenfall. On the one hand, the resource interfaces developed in interaction with potential users in the using setting (or in this case set standards and declaration of interests) were both heavy in terms of adaptations and specific using the terminology in Prenkert *et al.* (2019). On the other hand, the case illustrates how the new resource is anchored in the using setting already from initial stages. Importantly, this is the reason why this case is a case of resource renewal since the start-up's efforts were aimed towards replacing one particular resource based on requirements set in the using setting early on. The idea how to embed the wood tower in the using setting set the conditions for heaviness in the developing setting and the producing setting.

Looking at *the developing setting*, the prototype development is key. For example, the mixed interface between the wood tower and the wind power industry's organisational structure in the using setting revealed the need for the tower to be a certain height and able to carry larger wind turbines. If this had not been achieved, it would have been challenging for Modvion to become part of the Swedish energy system. This in turn affected how other resource interfaces between the wood tower and the resources belonging to developing partners such as RISE and the master's thesis students, as well as producing partners such as Moelven developed. Heaviness in relation to the wood tower was not as apparent in the developing setting as in the using setting, but the variety of the resource is still specific in the terminology by Prenkert *et al.* (2019), but not as heavy and specific as in the using setting. Both RISE's laboratory and SWPTC had resources that could be adapted to the needs of the tower, in terms of changing parameters of computer programs and adapting the site at Björkö.

Moreover, resource interaction in terms of adapting existing resources could also be seen in relation to potential suppliers in *the producing setting*. Firstly, Moelven had to reassign its staff from ongoing operations to the new production line built for producing Modvion's wood towers. It also had to order a new type of wood from its suppliers to meet the required functionality of the wood tower set by Modvion. Secondly, the painting firm Teknos had to adapt its paint system to enable

Table 2 Resource interaction in the case of Modvion

		Resource interfaces and learnings		
Business network settings:	**Business interaction partners**	**Technical resource interfaces**	**Organisational resource interfaces**	**Mixed resource interfaces**
Developing setting	Developing partners involved in projects funded by the Swedish Energy Agency such as RISE, interaction with university through master's thesis projects and research centre SWPTC	Wood tower ↔ SWPTC's site on Björkö *Learning: how to produce the new foundation, integrate sensors and build a new road on Björkö* Wood tower ↔ RISE's computer program *Learning: to understand the level of resonance when putting the wind turbine on the wood tower*	Modvion ↔ SWPTC *Learning: experience and knowledge of wind power development and research*	Wood tower ↔ the master's thesis students *Learning: how to construct the wood tower when it comes to the LVL layers and joints*
Producing setting	Moelven, supplier and development partner of glulam beams Teknos, supplier of paint	Wood tower ↔ Moelven's production facility *Learning: developing specific 3 D models and adding an extra production line* Moelven's production facility ↔ supplier facility *Learning: adding new steps in the purchasing process of wood* Wood tower ↔ Teknos' facility *Learning: adjusted a painting system to the wooden towers*	Modvion ↔ Moelven *Learning: sharing experience on glulam beam production*	Moelven's production facility ↔ the employees at Moelven *Learning: new staff routines to produce the specific glulam beams required*
Using setting	Governmental authority Wind power industry Interaction with potential users (energy companies)		Modvion ↔ the wind power industry's organisational structure *Learning: knowledge on specific trends and requirements early on; taller towers, larger rotors and sustainable materials* Modvion ↔ Swedish regulations *Learning: building stackable parts to meet the regulations on load dimensions* Modvion ↔ declaration of interest by future users Varbergs Energi, Rabbalshede Kraft and Vattenfall. *Learning: wood tower interfaces needed to be in place*	Wood tower ↔ the wind power industry's organisational structure *Learning: produce a 150-metre-tall tower in wood* Wood tower ↔ Swedish regulations *Learning: the tower will be comprised of stackable parts*

good functionality of the coating solution to suit the weather conditions of the wood tower. Thus, several resources had to be adapted and recombined to enable the tower to be built and the resource interfaces are regarded as heavy and general in the terminology by Prenkert *et al.* (2019). Hence, the producing setting was not characterised by heaviness in the same way as the using setting, based on the many ways of connecting resources to the wood tower being a sign of variety.

6. Concluding discussion and implications

Based on the case analysis above, we can conclude that resource renewal in heavy business networks from a start-up perspective, in this case, involved replacing one specific resource. This form of resource renewal requires the development of relevant resource interfaces in all three business network settings. The case analysis shows that the heaviness explicated in the using setting formed the heaviness in the developing and producing setting. Industry standards and signed declarations of interests with potential users in the using setting resulted in heaviness for resource interfaces in the other settings.

6.1 A start-up's perspective: resource renewal in heavy business networks

This form of resource renewal is made possible through enormous efforts by the focal start-up in relation to interaction with individual counterparts and creating resource interfaces in the three business network settings. The developing and producing settings account for the main collaboration partners and resource interaction especially with regard to technical interfaces. The using setting is characterised by meeting standards in terms of the height of the wood tower and early contacts with energy companies interested in ordering the towers. Consequently, the definition of the using setting can be broaden, in terms of including not only customers and users but also governmental authorities and industry related actors. The collaboration partners in the developing setting include research institutes, a pattern which is also observed in relation to other start-ups in early phases (Laage-Hellman *et al.*, 2020). Prototype development was key to testing the wood tower under real circumstances and played an important role in attracting collaboration partners in the developing setting and securing funding from a national funding agency.

This study provides new details regarding how start-ups approach business networks (Baraldi *et al.*, 2019; Laari-Salmela *et al.*, 2019; McGrath *et al.*, 2019). The details include first, how the resource interfaces in the using setting sets the grounds for heaviness in the developing and producing settings and causes narrow scopes for resources interfaces. Second how the resource interaction in the producing setting with potential suppliers plays a key role in bringing variety, and resource adaptations by suppliers are necessary to cope with heaviness in terms of, e.g. industry standards in the using setting and fulfilling declarations of interests. Variety is needed for renewal and in this case the producing setting is contributing with variety to achieve resource renewal. From a start-up perspective, aiming for resource renewal through aligning fully with the heaviness set from resource interfaces in the using setting may be a viable strategy considering that developing and producing setting provide the variety needed to accomplish this process.

The paper contributes to identifying a form of resource renewal in business networks enabled by development of resource interfaces in three business network settings (Håkansson and Waluszewski, 2007). Renewal in terms of replacing specific resource elements is an interactive but not straightforward process. This assumes that the resource interfaces were managed in the right way and that relevant standardised resource interfaces (Prenkert *et al.*, 2019) become reference points. In the case above, the resource interfaces in the producing setting were easier to adapt compared to the more specific resources in the using setting. The resources in the using setting were not easy to change; however, the industry standards in the using setting forced new resource combinations between actors in the producing setting. This situation, in which the resource interfaces emerge as being more important than the resource itself, is also observed by Bocconcelli *et al.* (2018) and Huemer and Wang (2021). One reason for the difference between the producing and using settings from the start-up's point of view could be that the start-up found suppliers outside the conventional energy system that see the opportunity to find a new market related to the energy field and are thus willing to make adaptations. Interacting with collaboration partners outside the heavy system was a requirement.

6.2 Implications for managers and future research

Start-up managers as well as established firms need to interact with a number of actors to create and develop the resource interfaces that underlie resource renewal. Resource renewal is not only in the hands of start-ups but requires interactive resource development with various collaboration partners. Development partners may be found in research institutes, research centres and support from national funding agencies are helpful to provide support in the developing setting. The using setting also builds on early interaction with potential users, which is important to be sensitive to future trends in the energy sector, but not necessarily future users need to be involved in the development.

This study provides evidence of functional collaboration with suppliers. The role of supplier relationships for start-ups has a wide scope, ranging from pure input suppliers to partners in co-development. Managerial implications following from this study is that from a start-up's perspective, one way forward could be to anchor the idea in the producing setting and teaming up with suppliers, that are able to replace parts of their existing resources with new resource combinations. This in turn will lead to a more useful resource that will eventually replace the existing ones in the using setting, and consequently bring renewal in business networks.

Understanding the intricate phenomena of resource renewal in business networks requires further empirical studies using an interactive lens and methodology. Individual resources may be replaced to implement innovations. However, to reach scalability, resource renewal requires radical efforts involving resource constellations way beyond the replaced resource and its interfaces. More needs to be learnt about the scalability of resource renewal. Business networks such as the ones underlying the Swedish energy system are, on the one hand, rather inflexible with regard to actors that have not adapted to cope with a certain business exchange partner, but on the other, the actors that have already adapted to certain standards set by the system can operate in it without friction.

For start-up managers in a context characterised by diverse expectations on future alternatives, there is a continued need to understand the mutual aspects of resource interaction in business networks. Learning more about the collaboration patterns between start-ups and other actors, such as suppliers in different contexts, is an important avenue for future research.

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