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Start-ups in Business Networks:

Resource Development through Interaction

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ABSTRACT

This licentiate thesis deals with start-ups' processes of relating to existing components in the business network in order to develop their innovations and become embedded in it. Previous research has shown that technology-based start-ups rely on external resources through collaborative business partners in order to create innovation. However, how this is done and what effects these collaborations have on the innovation and network itself is an area that needs further study. This licentiate thesis therefore aims to contribute to extending the knowledge of the interactive innovation process for technology-based start-ups by taking the starting point in the start-ups' resources and how they are combined in the business network.

The theoretical starting point is taken in the Industrial Network Approach to industrial markets and, more specifically, the process of resource development through interaction in the business network by seeing the innovations as a result of a number of resource combinations taking place in it. The method used is a case study of three cases that illustrate three different innovation processes for technology-based start-ups to capture resource development in business networks over time.

This study shows that these start-ups are in great need of adapting their resource features to fit into the existing resource constellations in the developing, producing and using settings in order to innovate. It is also relevant to approach collaboration partners that are willing to adapt their own resource collections to allow the start-up's resources to fit into their existing resource structures. Furthermore, the adaptations made in one resource interface impacts other connected resource interfaces, causing friction. Specifically, and as this study reveals, relating in business networks is a way of handling friction, which is a continuous interplay between triggers and changes in the resource interfaces. As a result, the important part lies in creating an understanding of how a specific change in one specific resource interface triggers a new change in a connected resource interface over time.

From a managerial point of view, the start-up needs to be aware of the importance of working with proximity of the three settings of developing, producing and using to allow it to embed its resources into the business network. Furthermore, it is relevant to find collaboration partners that are willing to make adaptations to their own resource collections. From a theoretical point of view, this study contributes additional knowledge to the study of resource development as a process by exhibiting the underlying mechanisms of why changes in resource interfaces take place and their consequences.

KEYWORDS

Start-ups, Business Networks, Interaction, Resources, Interfaces, Resource Development

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Maria Landqvist
Gothenburg, 2017

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“Almost every time I meet someone new, whether it is an end-user or a partner, I learn something new. That’s why we have said that it is important to continue meeting new actors”

– CEO of Aqua Robur

1. Introduction

This study deals with start-ups' processes of relating to existing components in the business network in order to develop their innovations and become embedded in it. In particular, this study deals with technology-based start-ups that are created at universities and whose ideas stem from both researchers and companies. To commercialize the ideas, it is necessary to understand what the users are actually willing to pay for at an early stage of product development. Developing business relationships with customers and learning in interaction with them, as part of the product development, has been recognized as an important part of becoming established (see eg. Aaboen, Dubois, & Lind, 2011; Blank, 2013; Chorev & Anderson, 2006; Laage-Hellman, Landqvist, & Lind, 2017b). The innovation process is often a result of an interactive procedure that includes different connections between firms and individuals (see eg. Antonelli, 1996; Lundvall, 2010; Powell, 1998; Rothwell, 1994). According to von Hippel (1988), the activities of discovering the idea, putting it into use and spreading it across markets do not follow a straight line, and the source of innovation can vary significantly, originating from not only the company itself or the researcher but also the users of the innovation or suppliers of the company. Furthermore, Pekkarinen and Harmaakorpi (2006) point out universities, technology centres and development organizations as important partners when developing new ideas.

Collaboration with external partners is particularly important to technology-based start-ups, as they often lack significant resources (Antolín-López, Céspedes-Lorente, García-de-Frutos, Martínez-del-Río, & Pérez-Valls, 2015; Baum, Calabrese, & Silverman, 2000; Coviello & Joseph, 2012). Previous studies have mainly focused on the entrepreneur's personal relationships. For example, the entrepreneur's network is seen as a starting point for the emerging company's initial network (Bhidé, 1999; Hallen, 2008; Hite & Hesterly, 2001). When it comes to the network development of start-ups, Elfring and Hulsink (2007) distinguish between different types of relationships. The entrepreneur's ties to family and previous professional relationships can be seen as strong and play an important role in the emergent phase of the new firm. As the firm tries to expand to new markets, it will add weak ties, which can help in the search for information leading to new business partners and business opportunities.

However, it is not only the entrepreneur's personal relationships that are important when trying to establish a new firm. As Huang, Lai, and Lo (2012) emphasize, it is through its business network, which consists of, for example, suppliers, customers and competitors, that the start-up can gain access to the resources it lacks. Researchers building on the Industrial Network Approach, also referred to as the Industrial Marketing and Purchasing (IMP) tradition, have recently begun to study the start-up as a phenomenon in business networks.

These researchers have taken the view of the start-up as a business unit in need of new business relationships and of starting up in business networks (see eg. Aaboen, La Rocca, Lind, Perna, & Shih, 2017; La Rocca, Ford, & Snehota, 2013; La Rocca & Perna, 2014). The IMP tradition emphasizes the importance of considering companies not as isolated units but as interconnected with other companies through interaction and business relationships in network structures (Håkansson, 1982, 1987). A business relationship created between two companies also affects other companies' relationships, leading to the development of a network of interconnected relationships (Anderson, Håkansson, & Johanson, 1994; Håkansson, Ford, Gadde, Snehota, & Waluszewski, 2009; Håkansson & Snehota, 1995). A business relationship consists of various aspects, such as social, technical, environmental and administrative. These aspects in turn create interdependencies between firms, as the linking of activities and resources calls for adaptations and formations of routines between the firms (Håkansson et al., 2009). Consequently, taking the starting point in the business relationship not only captures the social bonds but also the technical and organizational aspects of business networks.

The overall aim of this study is to develop an understanding of how start-ups relate to different components in business networks, such as other firms and resources. This aim is achieved using the Industrial Network Approach, emphasizing interactive development processes between firms (Baraldi, 2003; Holmen, 2001; Håkansson, 1989; Håkansson & Waluszewski, 2002a, 2007; Ingemansson, 2010; Laage-Hellman, 1989; Wagrell, 2017). This will help in understanding the complex and interactive process of innovation, specifically with the starting point in start-ups. As start-ups initially often lack established business relationships, it is important to understand how they relate to different components in the existing network in order to become established (Aaboen et al., 2011; Aaboen, Laage-Hellman, Lind, Öberg, & Shih, 2016; Laage-Hellman, 2012). An interactive view of the innovation process shows that an innovation is a result of allowing the start-ups' resources to interact with the existing resource collections of other firms (Aaboen et al., 2016; Ciabuschi, Perna, & Snehota, 2012).

To achieve this aim, a qualitative method is used to study start-ups originating from the incubator linked to Chalmers School of Entrepreneurship. Aaboen et al. (2011) suggest a longitudinal study to gain an understanding of the way the initial relationships impact the direction of the future development of start-up firms. Capturing the start-up's relationships in the business network over a long period of time makes it possible to follow the changes that occur and identify critical steps in the establishment process. As Bizzi and Langley (2012, p. 227) emphasize: "*Real-time research designs, on the other hand, are of particular value in capturing the ongoing development of networks in rich detail as they emerge.*"

Particular attention will be devoted to the resource interfaces that are created between the start-up and other actors in the business network and the way the resources are combined to create value for the involved parties over time. This is in line with Baraldi, Gressetvold, and Harrison (2012, p. 273) who call for a process view of resource interaction: *"So far, a majority of the studies focus on resource interaction in inter-organizational networks from a predominately structural side […]. Few studies have focused on depicting or conceptualizing process and dynamics within the resource interaction approach. Business networks evolve over time, and it is therefore highly relevant to study these phenomena from a processual point of view."* Furthermore, by taking advantage of the early stage of development of the start-up, and consequently the small number of business relationships that have developed, it is possible to obtain a clear picture of the business relationship development and the process of starting up in business networks (Aaboen et al., 2017). The start-up is used as a means to understand the business network, and particularly *relating* as a phenomenon in business networks.

The thesis is structured as follows. After the introduction chapter, the theoretical frame of reference, including the theoretical concepts linked to the Industrial Network Approach, is presented. The chapter ends with a problem discussion and research questions. The methodology of the study is then introduced, followed by the three case descriptions and the resulting case analysis. The thesis ends with a concluding discussion and suggestions for further research.

2. Theoretical frame of reference

As pointed out in the introduction chapter, the overall aim of this thesis is to develop an understanding of how start-ups relate to different components in business networks and, hence, the theoretical starting point is taken in the Industrial Network Approach to industrial markets. To analyse how start-ups relate to different components in the business network, theoretical concepts are required. Consequently, this chapter starts by introducing the assumptions of the Industrial Network Approach and then continues with the start-ups' interaction patterns in business networks. To analyse the effects of the interaction on both the start-up's innovation and the network, the concept of resource interaction in business networks is then presented.

2.1 The Industrial Network Approach

The Industrial Marketing and Purchasing (IMP) research tradition has its foundation in a number of empirical studies conducted in the mid-1970s and early 1980s. The studies were a result of the limited use of existing frameworks that explained common phenomena in business markets and these studies showed that there is more than just economic exchange between companies. Instead, there were empirical observations of long-term business relationships between firms that made companies dependent on each other (Håkansson et al., 2009). The first IMP study, including a study of relationships between a number of buying and selling companies, revealed that the relationships between the companies involved play an important role, as they are both resources and burdens for the firms (Håkansson, 1982).

In order to analyse what happens between two companies that interact in industrial markets, Håkansson (1982) suggests four crucial variables: the companies involved in the interaction, the elements and process of the interaction, the environment where the interaction takes place, and the atmosphere between the interacting companies. Ford (1980) also emphasizes that the interaction between two companies is influenced by previous experiences in the relationship and the expectation of future activities. As Håkansson and Waluszewski (2002a, p. 13) clarify, from an IMP approach, interaction is *"[…] understood as being directed towards clearly defined counterparts. Second, this interaction is assumed to result in different strata, affecting social, economic and technical features."*

The second IMP study went deeper and explored what actually constitutes a business relationship and how the dyadic relationship affects other relationships, resulting in a network of interconnected relationships. Håkansson (1987) points out three important parts of an industrial network: firstly, the *actors* involved in the relationships, for example the companies themselves; secondly, the *activities* performed by the actors; and thirdly the *resources* used to perform the activities. It is important to emphasize that the process of linking the activities of two companies requires both adaptation and formation of routines (Håkansson & Snehota, 1989). The adjustments that take place in one business relationship will also affect firms indirectly connected to the business relationship and consequently create connectedness between the firms (Anderson et al., 1994).

The network model referred to as the ARA model (Håkansson, 1987) was therefore developed. It takes into account the internal activities and resources in each company and in each business relationship as well as how they are linked to other actors in the business network. Håkansson and Snehota (1995) introduced the concepts of layers of actors, resources and activities, stretching from company level to relationship and network level. Firstly, the activity layer consists of internal activities that are linked within the company as well as with the actors in the network and, as a result, form *activity patterns* (Håkansson & Snehota, 1995). By adjusting the activities inside as well as outside the firm's boundary to improve joint performance, interdependencies between activities are created (Dubois, 1998; Gadde, Håkansson, & Persson, 2010). Secondly, in the resource layer, the resources are combined either as a collection of resources within the company or between the different actors as *resource constellations* connected through resource ties (Håkansson & Snehota, 1995). Furthermore, resources are confronted, adapted and combined. The value of a resource is therefore dependent on how it is connected to other resources (Håkansson, 1987; Håkansson & Waluszewski, 2002a). Thirdly, the actors themselves are connected in a *web of actors* that forms a network through the actors' bonds (Håkansson & Snehota, 1995). Accordingly, there are restrictions when it comes to autonomy and control in the business network because the companies need to adjust to each other's processes. Thus, it can be concluded that no company works in isolation but is dependent on other companies to create value (Håkansson, 1987; Håkansson & Snehota, 1989, 1995).

2.2 Start-ups' interaction in three business network settings

Previous studies in the IMP tradition have mostly concerned established firms (see eg. Håkansson, 1982, 1987; Håkansson & Snehota, 1995). However, interaction, which Håkansson and Waluszewski (2002a) refer to as directed towards a specific counterpart and as affecting social, economic and technical features, occurs whether firms are new or established (Aaboen et al., 2011; Aaboen et al., 2017; Strömsten & Waluszewski, 2012). A new venture can never emerge in isolation, only in a network consisting of resource constellations, activity patterns and a web of actors (Ciabuschi et al., 2012; Snehota, 2011).

According to La Rocca and Perna (2014), opening up an existing network to a new actor involves redesigning it and undermining parts of it. The new company must conform to the current actors' practices and be able to confront them by forcing the existing actors to develop new and better solutions to fit the new relationship (Aaboen et al., 2016).

Several important activities take place in the business network, some of which are related to the firms' product development processes, i.e. technological innovation is a result of interaction between firms (Håkansson, 1987). With the above reasoning on resource interaction in mind, an innovation can be seen as a new solution created through a combination of existing and new resources (Håkansson & Waluszewski, 2002a). Thus, to be able to create an innovation, existing resources located inside the firm need to be combined with others located outside the firm's boundary. As a result, a new technical solution will not be utilized in isolation but integrated with present technical solutions and activities to make it valuable (Ingemansson, 2010). The resources must function in different environments, from both a producing and a using perspective (Håkansson & Waluszewski, 2002a). That is, a resource must adapt both to the producing context, where it has to fit with the existing resources such as machines and equipment, and to the using context and the user's products (Håkansson & Waluszewski, 2007) regardless of whether the innovation has its source in science or business.

Hence, to create a new solution, the start-up needs to combine its own resources in what Håkansson and Waluszewski (2007) describe as three different business network settings: the developing setting, the producing setting and the using setting. In other words, to generate business and start growing, such firms need to establish themselves in networks by developing relationships with customers, suppliers and other types of business partners (Aaboen et al., 2017). Each setting is described below in terms of the type of actors (and the resource collections belonging to them) with which the start-up may need to combine its resources to be able to develop, produce and use its innovation.

The *developing setting* consists of researchers or other actors looking for new solutions. It is a trial-and-error process that is often costly and takes a long time since it can be difficult to know exactly what the customer needs or how the innovation will be able to fit into future production facilities (Håkansson & Waluszewski, 2007). As small firms often lack resources (Baum et al., 2000), it is important to integrate external actors into the development process. The future customer or user of the potential product is an important actor that has huge influence on the direction of the product development of the start-up (Aaboen et al., 2011; Laage-Hellman, Landqvist, & Lind, 2017a). In general, companies view customers as a source of competence that can bring knowledge and skills to the product development (Prahalad & Ramaswamy, 2000). As observed by Laage-Hellman et al. (2017b), the product development collaboration with customers can be focused or broad.

This means that some start-ups concentrate their efforts on developing one application area with one specific customer, while others work more broadly, and hence on parallel tracks, collaborating with several customers and several application areas at the same time. Sometimes, one application area is developed with several customers. The university is also perceived as an important actor when it comes to technology transfer and provision of new knowledge (Bercovitz & Feldman, 2006). Thus, it can have an important role in developing the start-up's product in terms of sharing laboratory equipment and knowledge (Laage-Hellman et al., 2017b). The incubator can also be an important actor that supports the development of new firms by providing office space and other resources such as networking capabilities and financial support (Baraldi & Havenvid, 2016; Cooper, 1985; Mian, 1997).

The *producing setting* is where the patent or prototype is transformed into a product or process. At this stage, the production will be influenced by the company itself as well as by other actors such as suppliers and sub-suppliers (Ingemansson & Waluszewski, 2009). According to Waluszewski (2011), the challenge in the producing setting is knowing how to embed the new solution into a supplying network, i.e. how to make use of and adapt existing production facility systems to fit the new solution. As Håkansson and Waluszewski (2007) point out, it is a matter of trying to use existing resources at the production facility and, as Handfield, Ragatz, Peterson, and Monczka (1999) emphasize, allowing the supplier to provide innovative technologies to the start-up. From the point of view of a start-up, this is highly relevant as it can reduce product development costs and time to market for the company (Ragatz, Handfield, & Scannell, 1997). According to Song and Di Benedetto (2008), the relationship between the supplier and the new venture has unique characteristics due to the dependencies created between the two firms, specifically, the integration of suppliers will often provide not only new technologies but also financial support.

The *using setting* is where the resource can become an innovation; that is, a product or process that customers or users are willing to use in their own production processes (Håkansson & Waluszewski, 2007). By collaborating with potential and existing customers during the product development process, the distance between the developing and using settings can be decreased. As Prahalad and Ramaswamy (2000) emphasize, customers are a source of competence and can guide the product development process in the right direction by providing knowledge about existing processes in which the start-up's resources will hopefully become embedded. Consequently, to make use of a new solution, the start-up's resources need to be combined with other resources located outside the company's boundary (Aaboen et al., 2016). Depending on how many companies are willing to use the innovation, it can get widespread use or be ignored. Figure 1 illustrates the start-up's interaction in three business network settings.

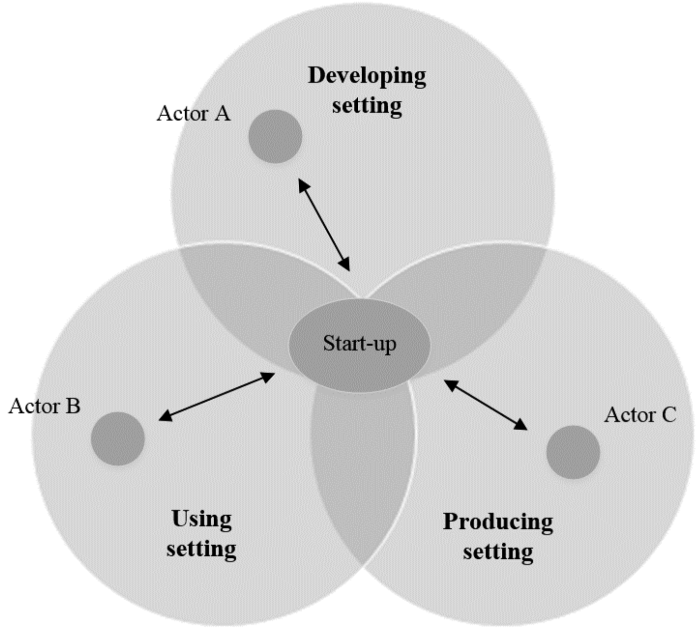


Figure 1. The three business network settings in which the start-up tries to interact with different actors

2.3 Resource development through interaction in business networks

It is now of interest to dig deeper into the concepts of resources as they play an important role in the technical development of start-up firms. As stated by Håkansson and Snehota (1995), an element (tangible or intangible) is considered a resource when it has a *known use* in relation to other elements. In turn, the value of a resource is dependent on how it is used, both within the resource collection and across firm boundaries. Resources are thereby seen as heterogeneous (Alchian & Demsetz, 1972; Penrose, 1995 {1959}), and the value of each resource is in itself dependent on how it is combined with others (Håkansson & Waluszewski, 2002a). That is, each resource is reliant on its connections to other resources, and it changes and develops its features over time (Baraldi & Waluszewski, 2005; Håkansson & Waluszewski, 2007). Consequently, by confronting and adapting the resources through interaction, value is created. When considering resource heterogeneity from an Industrial Network Approach, emphasis is put on how the single resource can be utilized in different combinations. Holmen (2001) presented the concept of resource versatility to explain how a resource can be used. Versatility can be achieved either by combining a resource with another, which in turn results in a completely new resource that will fit better with the existing resource constellation, or through modifications, i.e. by changing the features of the resource to achieve a better fit. That said, a resource always has unknown characteristics as there are always new ways to combine it with present or new resources (Baraldi et al., 2012; Håkansson & Waluszewski, 2002a; Lind, 2006). Holmen (2001) takes it one step further by discussing the importance of *potential use* and value: "*Resources can also be defined in relation to potential use and value […] this is turn would imply that existence, possibly linked with expectations as to potential use would be the main criterion for assessing whether an element would qualify as a resource.*"

2.3.1 Organizational and technical resource development in interaction

Håkansson and Waluszewski (2002a) identified four types of resources belonging to either technical or organizational forms. Firstly, there are *products*, which can be single items or a system comprising not only the item itself but also additional services. The product can also, for example, be part of the buyer's product and therefore have to be adapted to suit the end product. Secondly, there are *facilities*. Connecting facilities enables companies to save time and money and is therefore a vital part of the relationship. The third resource is the *business unit,* including social resources, such as knowledge about the corresponding company and an understanding of how to work with it. Observing the interaction from a more social perspective puts the focus on characteristics such as motivation and ability to cooperate. The fourth resource is the *business relationship*, which is strongly connected to time and through passed interaction and future plans between firms. It can be used as a way to support a company and relate resources to each other. Hence, it presents both limitations and opportunities over time for the companies involved. The four categories of resources can be summarized in the 4R model. As Baraldi et al. (2012) emphasize in their conclusions, the 4R model can be seen as a fine-grained tool for mapping and analysing resources and connected interaction processes in inter-organizational innovation processes. Thus, as concluded by Gressetvold (2004), these four resource types are interrelated, i.e. the technical and organizational resources can be combined in one way or another, for example when a product is developed through interaction with other resources, such as a facility or equipment, it will influence both the directly connected resources and the indirectly connected ones over time.

Gadde et al. (2010) explain three types of resource combining. The first type involves combining new resources with existing ones. Adding a new resource to an existing collection will not always go smoothly. Every resource carries prints of past structures and processes, which affect how it will fit into the new context of existing resource structures. As mentioned above, the internal resources should not be considered isolated from their surroundings (Håkansson & Snehota, 1995), but can be combined across the firm boundary. As Gadde et al. (2010) point out, combining resources across firm boundaries involves a number of tasks, such as evaluating the internal resources in order to understand the need for external ones as well as handling and coordinating the external resources. The third type is related to the connection between the context where the resource is produced and the one in which it is later used. The resource as such has what Gadde et al. (2010) call a "*double-faced*" nature. For example, the supplier of the resource needs to be aware of which context the resource will be used in (Harrison & Waluszewski, 2008; Håkansson & Waluszewski, 2002a).

In the context of innovation and combining new resources with existing ones, it is also important to consider the interplay between the idea and the existing resource structure. As Håkansson and Waluszewski (2002a) point out it is important to understand how much advantage an idea can gain from current solutions as well as how much the existing resource structure is reflected in the idea. It is a continuous adaptation between the ideas and the 'activated resource structure' in which all affected actors need to participate.

2.3.2 Resources and their interfaces

When technical and organizational resources interact, both within firms and across firm boundaries, the value of the new resource depends on how the existing resources are combined and, consequently, how the interface develops between them (Baraldi et al., 2012). In every resource combination, the contact points between resources are referred to as interfaces. How the interfaces develop depends on how the features of the resources can be adapted to each other (Gadde & Håkansson, 1993). Three types of resource interfaces can be identified. Firstly, Dubois and Araujo (2006) categorize two types of resource interfaces: *technical* and *organizational*, which become visible when two technical or two organizational resources interact with each other. Secondly, Jahre, Gadde, Håkansson, Harrison, and Persson (2006) point out the *mixed* interface as a result of a combination of one organizational and one technical resource.

As Gadde and Håkansson (1993) emphasize, the resources can be seen as pieces of a puzzle that have initially not been shaped to fit the common puzzle. Thus, the interfaces between them may not fit, and the resources may therefore need to be adapted to each other. With regard to the interface between two technical resources, Dubois and Araujo (2006)'s study revealed how one specific resource feature could affect the individual component (or resource), the interface between the component and the other resource, and the connected interfaces. It is therefore important to consider not only the technical features of the two components and how they may change but also the features that belong to the interface itself as well as those that belong to the network. Furthermore, the interfaces between two organizational resources are characterized by, for example, the way teams can coordinate activities and the adaptations that will need to be made to meet the changes in the technical interfaces. They are all interrelated, and since they will affect and be affected by each other they will also need to be dealt with holistically.

Moreover, interfaces not only become visible between resources of the same type but also between technical and organizational ones. Jahre et al. (2006) argue that this kind of interface is more complex than those occurring between the same types of resources. One reason for this is the economic aspect connected to the organizational resources. However, it is also in these interfaces that value is generated by embedding the technical resources into organizational structures. Hence, it is seen as a dynamic process in which there is no stable solution for a long time and there is a need to constantly let resources interact with each other to improve the fit between them.

When considering resource interfaces from a holistic point of view and, particularly the way connected interfaces impact each other, it becomes clear that the value of a product does not necessarily depend on the product's internal features but on the way the interfaces develop between indirectly connected resources (Baraldi et al., 2012). This in turn can create what Håkansson and Waluszewski (2002a) call *heaviness*, which refers to the difficulty of disconnecting or recombining already combined resources. Heaviness can occur in, for example, industrial areas where many interfaces have been created between physical products with high economic value, such as, for example, the paper pulp industry (Håkansson & Waluszewski, 2002b). On the other hand, the resources available in the business network open up the opportunity for a huge number of combinations and thus new interfaces. This is a result of the *variety* of resources, namely how distinctive they are in relation to others and how they are combined (Håkansson & Waluszewski, 2002a). The concepts of *heaviness* and *variety* are thus important to understanding how firms can develop and manage their resources (Baraldi et al., 2012).

With regard to the specific features of the resources, some are known beforehand and some emerge through interaction with others. It can be said that it is in the interface between resources that their features are determined and their values shaped (Håkansson & Waluszewski, 2002a). Håkansson and Waluszewski (2002a, p. 192) give the following example of the way interaction between resources can affect the resource category of facilities, on the one hand, by developing unique features that result in heaviness and, on the other, making the facility less important in relation to other resources: "*through interaction processes between different resources that are adapted in relation to each other, some unique features of the facility are developed. These unique features are only activated in relation to some other specific features […] consequently, in relation to resources where no special features are developed and utilized, the facility can easily be compared with and replaced by others.*"

The adaptation or development of features in one specific interface may have an effect on the connected interfaces. Håkansson and Waluszewski (2002a) explain the concept of *friction* as the resulting reaction when directing a force towards a specific resource that already interacts with other resources. Håkansson and Waluszewski (2002a) identify the following effects of friction: (i) it will distribute the reaction to all resources that have interfaces with the focal resource, (ii) this in turn will create tensions in the interfaces between these resources and (iii) affect the resources differently given the specific point in time. Namely, friction is necessary to transform interfaces to enable a better fit between the interacting resources. It is through friction that new resource features can be established, resulting in new solutions. However, the heavier the resources are in relation to each other the harder it is to change and adapt the features in the specific interface. Connecting friction to the variety dimension implies that friction in one interface can affect other interfaces of the focal resource and hence create even more variety of resources. To summarize, friction is used as a tool to understand the interaction between resources whose features are relational. Figure 2 illustrates the focal interface RI_{1-2}, visible between the focal resource R_1 and resource R_2, and the connected interfaces RI_{1-4} and RI_{2-3}.

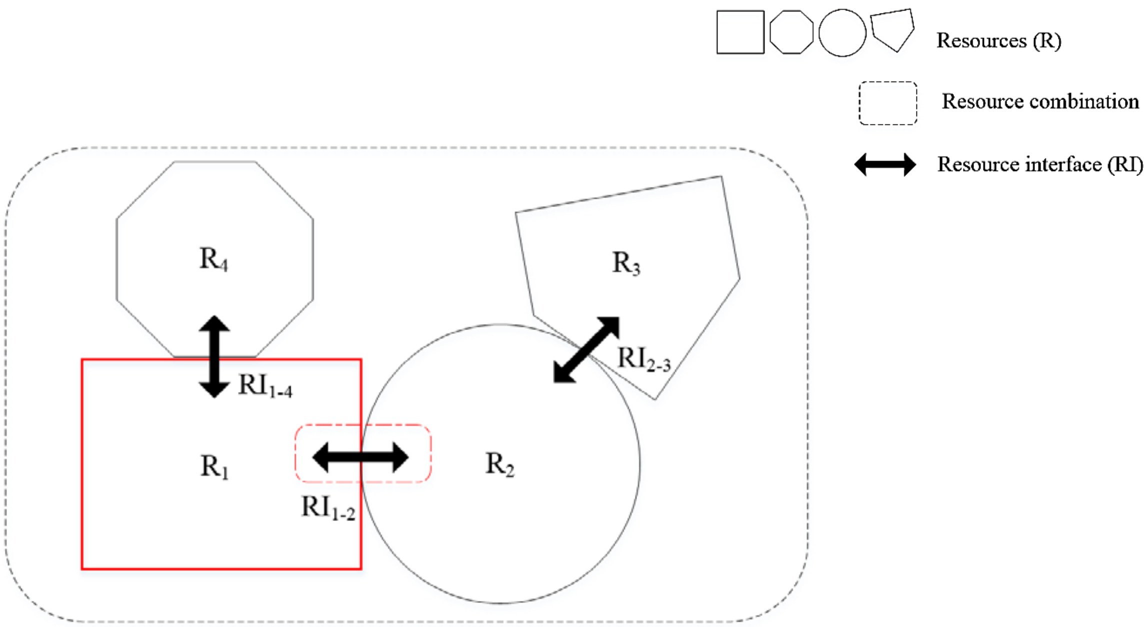


Figure 2. A conceptual model of the visible interface RI_{1-2} between two combined resources and their connected interfaces RI_{2-3} and RI_{1-4}

2.4 Problem discussion and research questions

The aim of this thesis is to develop an understanding of how start-ups relate to different components in business networks. Depending on the type of start-up and the context from which it stems, there are different ways of organizing the innovation process. One way to understand the innovation process is to take the perspective of the interactive business landscape (Håkansson et al., 2009). In order to develop, produce and reach users of an innovation, the start-up needs to be able to combine its own resource collections, including technical and organizational resources, with those of other actors (Håkansson & Waluszewski, 2002a). To do this, the start-up needs to create relationships with other actors within the developing, producing and using settings (Håkansson & Waluszewski, 2007). Resource combining in the different settings of developing, producing and using is neither a standardized nor a linear process. There are times when the three settings overlap; for example, when companies decide to develop the product in interaction with a potential customer to get a better understanding of what the customer wants or with a potential supplier to be able to produce the innovation in the future. To understand how a start-up relates to different components in the business network, it is therefore of interest to take the starting point in the innovation process and look at how the start-ups' resources are combined with those of other actors in the three business network settings and how the interfaces develop. As pointed out by Håkansson and Waluszewski (2002a), it is in the interface between two resources that the features of the resources are decided and their value shaped or, in other words, the potential innovation comes about. This leads to the first research question (RQ1):

- How are resources combined in the three business network settings?

Once it is known how the resources are combined in the three business network settings, it is interesting to look at how specific resource combinations affect what happens in other resource combinations or, in other words, resource interfaces. Dubois and Araujo (2006) emphasize the importance of considering the interface between two specific resources not as isolated but as affecting other connected interfaces in the business network, i.e. friction in one interface will distribute the change in one specific interface to other connected interfaces, calling for additional adaptations. That said, friction is essential to transform interfaces to allow a better fit between the interacting resources (Håkansson & Waluszewski, 2002a). To understand how a start-up relates to different components in the business network, it is therefore important to study how a change in one resource interface spreads to other connected interfaces. This leads to the second research question (RQ2):

- How are resource interfaces connected through interaction?

By conducting a longitudinal study and following the start-ups' innovation process over time, the various internal and external resources, as well as existing and new resources, that are combined can be captured. Furthermore, it will reveal how friction distributes the changes in one resource interface across the business network. In other words, this study takes a process view (Bizzi & Langley, 2012) of resource interaction in order to understand how start-ups relate to different components in business networks.

3. Methodology

This chapter discusses the methodology used in this thesis. It starts in the research context and the environment I was part of while conducting this study. The methodological choice of conducting a case study is then explained together with the research process and data collection. The chapter ends with a reflection on research quality.

3.1 The research context

This licentiate thesis takes its starting point in a project called *University entrepreneurship: The case of university spin-offs in a network perspective (USONET)*. The project, which includes researchers from Lund University, Örebro University and Chalmers University of Technology, started in January 2015 with the aim of contributing new knowledge on the complex process of commercializing science. This by analysing spin-offs in a network perspective in terms of how they interact in business networks in order to commercialize their ideas and study the effects of the interaction on the innovation, the spin-off itself and the network. Within the framework of the USONET project, the overall focus of this licentiate thesis is on how start-ups *relate* to different components in the network, such as other firms and resources, in order to innovate. In this thesis, the innovations do not only stem from a university context but also from other contexts such as existing businesses and independent entrepreneurs. From a theoretical point of view, the study has its starting point in the Industrial Network Approach to industrial markets, emphasizing interaction and interdependencies between firms. As the initial aim was to study the interaction between firms and thus use the business relationship as a unit of analysis, I knew the Industrial Network Approach could provide me with a good toolbox in terms of capturing the technical development in the interaction taking place between the firms, including start-ups and established firms in the business network.

Being a PhD student at the former division of Industrial Marketing at Chalmers University of Technology, which has since been merged into the division of Supply and Operations Management, has provided me with a good foundation of knowledge on which to approach my research project. Our research group has its theoretical starting point in the Industrial Network Approach, and by taking part in research seminars on regular basis as well as PhD student seminars given every six months in our division, I gained much valuable input during the process of conducting the study and writing this licentiate thesis. I have also attended two IMP conferences and other related workshops such as for example Nordic Workshop in Interorganisational study to broaden my knowledge within my field of research. Furthermore, during the two and a half years of this project, and beyond writing this thesis, I also had the opportunity to be part of writing a book chapter on the topic of starting up in business networks (Laage-Hellman et al., 2017b). Moreover, two additional papers were written in the project. One of them focuses on how technology-based start-ups collaborate with customers in product development and was presented at the 32nd IMP Conference in Poznán 2016 and now in press in the journal of Industrial Marketing Management (Laage-Hellman et al., 2017a). The other paper deals with networking behaviours of start-ups and looks in more detail at working with strong and weak ties in order to embed the start-ups' resources in the three business network settings (Landqvist & Lind, 2017). This paper has been submitted to an international journal within the field of industrial marketing and is now in the later stage of the review process. That said, this thesis gives an additional perspective on start-ups and their networking by looking deeper into the actual process of resource interaction.

3.2 A case study approach to capture resource development in industrial networks

As this thesis deals with interaction and technical development in business networks, an in-depth analysis of each specific start-up and its relationships with the surrounding actors was required to explore the effects of the interaction on the start-up's innovation and network over time. This is in line with Bryman and Bell (2015), who argued that in order to understand why someone acted in a specific way, the context must be understood and seen through the eyes of the people being studied. This means that I had to understand the context in which the start-ups operate, which called for a qualitative research approach (Bryman & Bell, 2015; Flick, 2014).

When considering the type of research design suitable for this qualitative study, case study research, a well-known and frequently used research method for studying organizations in networks (Easton, 2010; Gummesson, 2007; Piekkari, Plakoyiannaki, & Welch, 2010), was chosen as it is well suited to studying technical development in industrial networks. According to Eisenhardt and Graebner (2007, p. 25): *"case studies emphasize the rich, real-world context in which the phenomena occur."* Hence, building context-specific cases of how each unique start-up creates relationships with external actors enables an understanding of the underlying reasons and motivations for each relationship as well as how the business network functions. This is in line with Halinen and Törnroos (2005) who argue that a case strategy for studying networks is necessary as the separate unit (such as the relationship) is heavily dependent on its context. Furthermore, by using a process study approach (Bizzi &

Langley, 2012; Langley, Smallman, Tsoukas, & Van de Ven, 2013), and thereby collecting data both retrospectively and in real time, interesting patterns can be identified. By trying to identify the causes of the innovation having to be adapted and how it directed the development of the innovation, it was possible to contribute to the understanding of the start-ups' process of *relating* in the business network.

Conducting qualitative research is not an "*off-the-shelf*" process as Maxwell (2012) emphasizes. The parts of the research design therefore have to be reconsidered and matched to other parts such as the data collection, the conceptual framework and the research questions. This study was no exception, as will be evident in the following sections.

3.3 The research process

When it comes to the research process, there has been continuous interplay between the theoretical framework, the method and the empirical world (Dubois & Gibbert, 2010). By taking the theoretical starting point in the Industrial Network Approach and the ARA model (Håkansson & Snehota, 1995), I learnt that business relationships contain activities, resources and actors. By delving deeper into the literature I also came across the three business network settings of developing, producing and using (Håkansson & Waluszewski, 2007; Ingemansson, 2010), which provide a way of understanding how innovation takes place in business networks in the form of resource interaction. In my mind I perceived the start-ups as circulating strongly to find ways to reach out with their ideas and make them commercial, hence creating an innovation. This is done by trying to establish business relationships with other actors. Taking the starting point in the three business network settings and the ARA model, I saw the possibility of analysing how the start-up works on developing its idea (or resources) together with external actors through different activities in the context of the three settings. Namely, the initial aim was to study the interaction between the start-ups and other firms, and thus use the business relationship as a unit of analysis. When relationships are established in all three settings, the start-ups may be perceived as established since the idea has been developed, produced and finally used, a process that I assumed would not occur sequentially but in parallel in all three settings.

In this sense, the method of reasoning could first be seen as a deductive approach (Bryman & Bell, 2015) in which my interview guides were constructed around the three business network settings as well as the ARA model. However, studying processes and changes required an open approach in which I interacted with the empirical data and theory simultaneously. It therefore took the form of an abductive study in which I continuously matched my theoretical framework and case descriptions. When starting my case analysis during the transcription of the interviews and later the coding of the transcripts according to the ARA model and the three business network settings, I was able to start identifying the specific relationships and where they were located in the three settings. However, the data revealed a stronger connection to the actual resources and the importance of embedding the resources (or the products) in existing resource structures. This led me to start thinking about the 4R model (Håkansson & Waluszewski, 2002a) and focusing on resource combining in the three settings. As a result, the forthcoming interviews had a more precise focus on the resource combinations, by letting the interviewees talk in detail, and in their own words, about how their resources were combined with the other actors' facilities, business units and business relationships. Furthermore, as a way of better understanding the context, I also extended my data collection to include additional data sources such as newsletters, home pages and learning journals.

Coming back to the case analysis, I could see that it was hard to actually talk about a product (as part of the 4R model) since the algae, smart package and turbine were continuously being developed and hence were not products ready for purchase. As Håkansson and Waluszewski (2002a) also point out, there is a difficulty in treating an industrial product as given since its features are developed through interaction between the buyer and seller. In this case, the empirical world revealed greater focus on adapting the start-ups' innovation to developing partners, potential users and producers than actually selling an existing product. It was evident that the start-ups' innovations had characteristics that were not always in line with what the counterparts wished for. To understand this theoretically, I moved away from the 4R model and started to focus on the particular resource interfaces and features developed between technical and organizational resources (Dubois & Araujo, 2006; Gadde & Håkansson, 1993; Jahre et al., 2006) as well as the concept of friction (Håkansson & Waluszewski, 2002a), i.e. how a 'trigger' in one resource interface leads to 'change' in connected resource interfaces. These reactions were a result of the start-up's attempt to embed its resources into existing resource collections in the three business network settings and hence develop a valuable product. Paying closer attention to the resource interfaces impacted my data collection and hence created an interest in conducting a field trip and looking for reports and news articles that could reveal more details on the embedding of resources, in addition to the interviews that were carried out. As a result, the interplay between the theoretical framework, the method and the empirical world (Dubois & Gibbert, 2010) led to the two research questions

- How are resources combined in the three business network settings?
- How are resource interfaces connected through interaction?

The initial aim to study the interaction between the start-ups and other firms has been similar throughout the research process. However, the meaning of the aim has changed since during the process of finding my research questions I also realized the relevance of finding concepts that could capture this aim from a general perspective, given the understanding that the phenomenon was not specific to start-ups. Choosing the concept *relating* and how the start-ups relate to different components in the business network, such as actors and resources, became a possibility to open up for a general analysis where the start-up could act as a means to understand the business network and in particular resource development as a process.

Moreover, when going out into the empirical world I could sense that the study objects not only worked with existing business relationships but also tried, in parallel, to create opportunities for new business relationships by initiating discussions with new actors in all three settings. This empirical finding was too important to neglect as it is an essential part of the start-ups' effort in relating in the business network and finally reach resource combining. It therefore opened up the possibility of directing my theoretical framework to include not only resource combining but also less developed relationships. Concepts such as *episodes of relationships* (Gadde & Håkansson, 1993) and *strong* and *weak ties* (Granovetter, 1973) were of interest, but to avoid making the picture even more complex, the concept of *resource interfaces* was chosen in the analysis. The topic of networking behaviours, in terms of strong and weak ties, was addressed in parallel in the paper by (Landqvist & Lind, 2017), which is now under review. As the study proceeded, I also came across innovation and entrepreneurship literature in the additional papers and the book chapter I was part of writing. By continuously being exposed to these kinds of theories, through doctoral courses such as 'DREAM' given by Saras D. Sarasvathy[1], 'Management of Innovation & Technology: intra- and interorganizational perspectives' given by Uppsala University as well as the course 'Operation and Supply Chain Management' given at Chalmers University of Technology, I was able to appreciate the theories' contributions to the field and also see the relevance of using the Industrial Network Approach as a theoretical foundation to explain the phenomenon of start-ups and networking.

3.4 Data collection and analysis

Case study research often implies multiple sources of data (Yin, 2013). In this study, interviews, seminars and other secondary data have acted as a foundation on which to build

[1] Saras D. Sarasvathy is a professor at University of Virginia Darden School of Business and introduced the principle of Effectuation, which is related to the way entrepreneurs are thinking in the process of new venture creation.

my cases and create an understanding of what is for me a rather newly explored empirical context. That is, the earlier interviews and seminars helped me to orientate myself and guided me to select suitable study objects.

When this study started I had no significant experience of entrepreneurship. I therefore attended two seminars, and conducted one interview with a business coach at Chalmers School of Entrepreneurship and one with its director to get a sense of how entrepreneurial projects are carried out. Chalmers School of Entrepreneurship was a natural choice as an empirical context for several reasons, one main one being the strong connection to a technical university where most of the projects are created around a technical idea or product. As I wanted to study interaction and technical development in industrial networks, specifically for start-ups, it was well suited to the study. The incubator connected to the School of Entrepreneurship is based on surrogate entrepreneurship, which means that the technology developed by a researcher, company or private person is transferred to an entrepreneur (Radosevich, 1995) or, in this case, the students at Chalmers School of Entrepreneurship. Surrogate entrepreneurship also turned out to have a good impact on venture performance (Jo & Lee, 1996; Lundqvist, 2014) and in particular Chalmers School of Entrepreneurship has performed very well in different rankings[2]. Hence, as my research dealt with interaction and technical development in business networks, I saw a good opportunity to find suitable study objects within a close distance.

3.4.1 Selection of study objects at the outset of the study

In parallel with conducting the orientation interviews, I started to look for potential study objects. Easton (2010) suggests deeper and wider explanations when aiming for theory development. In this situation, the use of a multiple case study did not aim for statistical representativeness but to add variation to the empirical evidence and build an understanding of the phenomenon studied, in this case how start-ups relate to different components in business networks. To use a metaphor: the phenomenon is a circle composed of different parts (or cases), and each one on its own provides a deeper explanation of the mechanisms and processes underlying an event that is about to happen. Hence, the deeper explanations of specific events (or cases) together can provide a wider explanation of the phenomenon as such.

[2] In 2014 the incubator at Chalmers School of Entrepreneurship was ranked eighth in the world and second in Europe according to the UBI Index, which is a European research initiative that focuses on the University Incubator Benchmark.

When I started this study in 2015, I had a broad research focus. Beside the USONET project, as described above, no specific research question guided my choice of study objects. Only my initial aim of wanting to study how start-ups, as newly established firms with few business relationships but a clear need to develop them, interact in the business network. My choice of study objects was driven by my own interest in sustainable development and sustainable product solutions. Reading the homepage of the School of Entrepreneurship, I found several interesting projects, some of which were still running and others that had left the school. I contacted two projects that were still running at the incubator, namely WaterWeave and Aqua Robur. The first one focused on developing a smart textile to clean water and the second a turbine to produce electricity in a sustainable way. I also contacted one start-up founded in 2012, Swedish Algae Factory, that was trying to develop application areas linked to algae. This start-up was located at the Stena Center, which provides serviced offices for entrepreneurs and start-ups close to Chalmers University of Technology. I also had personal contact with the CEO of Mevia, a start-up developing a smart package for medicine intake, and the initial interview revealed that the start-up was selling products at the time. I thought this was very interesting and, as a result, I had four study objects with very exciting products which could help me start exploring how start-ups interact in the business network. Unfortunately, as time went by, WaterWeave dissolved as a project, resulting in three final study objects.

During the data collection and analysis, it became clear that even though the start-ups stemmed from the same context and all had technology-based products, their way of interacting in the business network varied. As time went on, the cases revealed different resource interaction patterns in the three business network settings in terms of how far they had come in embedding the resources in the three settings as well as with which components. Coming back to Easton (2010), I could now see that the three cases could provide a deeper explanation of a contextually based innovation process and, at the same time, a wider explanation of the phenomenon of *relating* as such.

3.4.2 Conducting interviews with the study objects

In order to grasp how Aqua Robur, Mevia and Swedish Algae Factory work with interaction in the three business network settings, data were collected retrospectively and in real time. For the latter, interviews were the main source of data. According to Kvale (2001), interviews are a suitable way of collecting data as they go beyond everyday discussions and provide in-depth knowledge about a certain phenomenon. Interviews are considered a flexible method of data collection (Easton, 2010) that opens up new topics for discussion, which is highly relevant when studying how things evolve over time.

Interviews were conducted with the three CEOs of the start-ups and they lasted one hour each (see Tables 1, 2 and 3). To get a clear picture of what was going on in the interaction, it was important to also interview the counterparts in the relationships. A number of key relationships with counterparts were selected, such as those with important development partners, suppliers and business partners. Interviews were then carried out with each counterpart. Each interview was recorded and transcribed shortly after it was finished. In some cases, I had to go back through emails or additional interviews for clarification. The interviews were conducted between 2015 and 2017. By allowing a few months to pass between the interviews with the CEOs of the start-ups I was able to follow up changes in the relationships. By conducting semi-structured interviews, which Bryman and Bell (2015) describe as a flexible interview process that allows for new topics of discussions, the interviewee was able to talk about important issues and events. This led to redirection in the empirical world and the theoretical framework, as seen in Section 3.3. All of the 17 interviews are explained in more detail below.

Table 1. Interviews related to Swedish Algae Factory in its network context

Interviewee	Number of interviews	Date of interview	Additional email contacts	Aim of interviews
CEO and founder of Swedish Algae Factory (founded as a project in 2012)	5	17/3-2015 23/4-2015 18/11-2015 13/5-2016 20/6-2017	Yes after each interview	Main source of data and study focus – a number of relationships in the developing setting
Development strategist at Sotenäs Symbioscenter	1	20/6-2017	No	To understand the context in which Swedish Algae Factory tries to embed its innovation

Table 2. Interviews related to Aqua Robur in its network context

Interviewee	Number of interviews	Date of interview	Additional email contacts	Aim of interviews
CEO and founder of Aqua Robur (founded as a project in 2014)	4	30/3-2015 27/11-2015 13/5-2016 17/3-2017	Yes after each interview	Main source of data and study focus – a number of relationships in the developing and producing settings
User and tester (Kretslopp och Vatten)	1	24/3-2017	Yes	To understand the collaboration between Aqua Robur and its developing partner/user

Table 3. Interviews related to Mevia in its network context

Interviewee	Number of interviews	Date of interview	Additional email contacts	Aim of interviews
CEO and founder of Mevia (founded as a project in 2012)	4	8/4-2015 11/11-2015 24/8-2016 22/5-2017	Yes after each interview	Main source of data and study focus – a number of relationships in all three settings
User and tester (Retirement home)	1	19/8-2016	No	To understand the collaboration between Mevia and its developing partner/potential user
Producer of prints	1	28/6-2016	No	To understand the collaboration between Mevia and its supplier

The interviews with the CEOs of the start-ups were supported by network pictures. This allowed patterns in the relationship development process to be identified and confirmed (Aaboen, Dubois, & Lind, 2012). The network pictures were developed from the theoretical framework (see Figure 1 in Chapter 2) and helped to build a structured view of the relationships in each setting. Furthermore, they acted as a tool to engage the interviewee in the discussion. It is important to note that these pictures were created from the interviewee's perspective. Figure 3 and 4, on the following page, are examples of two network pictures created during the interviews with Swedish Algae Factory (SAF) in 2015 and 2016. SAF is in the middle of the three settings, acting as a spider in the web, with the aim of developing and maintaining a number of relationships with different actors. The thick arrows depict business relationships and the dotted ones discussions.

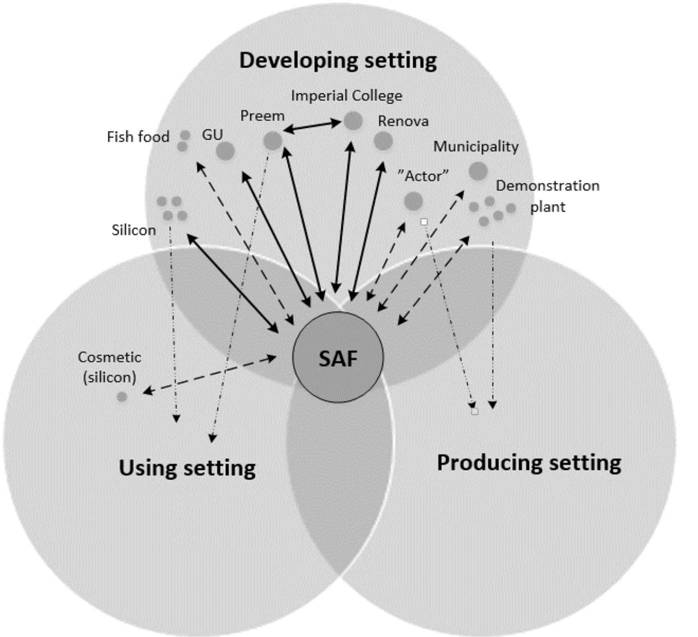


Figure 3. A network picture used during an interview with SAF in 2015

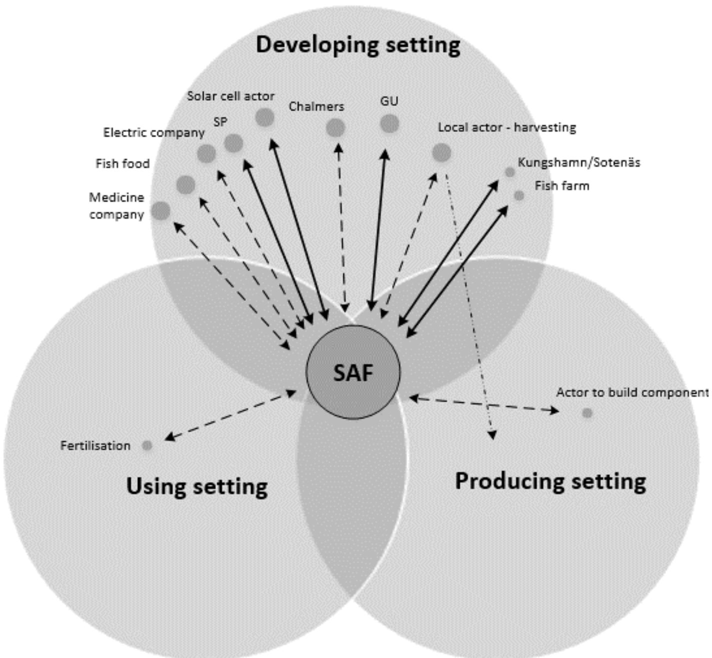


Figure 4. A network picture used during an interview with SAF in 2016

3.4.3 Additional data sources

In addition to the interviews, I kept myself updated on my three study objects' progress by relying on other types of data sources. All three start-ups had functioning webpages where news and updates on application areas were continuously reachable. Furthermore, I could follow Aqua Robur and Swedish Algae Factory on Twitter and Mevia's news could be read in monthly newsletters. Another valuable source of information was newspapers such as *Göteborgsposten* and industry magazines. Visibility seemed to be an important step for the start-ups to attract attention and hence create opportunities for collaboration and financial investments. Swedish Algae Factory also took part in the radio show 'Vetandes värld' on Swedish Radio P1 (Renström, 2016), which talked about algae cultivation in Sotenäs. All these updates have helped me to gain a clear picture of what is happening in the start-ups and given me the opportunity to create thorough case descriptions. Moreover, I had the opportunity to use a master thesis conducted at Chalmers University of Technology connected to the design of the new algae cultivation system in Sotenäs (Dankis, 2016) as well as a learning journal (a type of diary) from the CEO of Aqua Robur's first year as an entrepreneur at Chalmers School of Entrepreneurship. I also had the chance to visit the algae cultivation in Sotenäs, which gave me a good insight into the context in which Swedish Algae Factory operates.

3.5 Reflection on research quality

When it comes to the research quality of case study research, Dubois and Gadde (2014) stress two important issues. The first regards the presentation of the case study and how it relates to theoretical concepts, i.e. overcoming the problem of seeing case studies simply as rich descriptions of events put into pre-existing theoretical categories. The focus should be on matching the evolving case with the evolving theoretical framework (Dubois & Gadde, 2002). In this licentiate thesis, theory has acted as a resource that has guided the data collection and, vice versa, the findings in the data have guided the search for new theoretical concepts. A more detailed explanation of the matching process of the study has already been presented in Section 3.3.

The second issue regards the explanation of the methodological procedure underlying the case study. There are two ways to work with this. To begin with, Piekkari et al. (2010) emphasize the reflexivity of the process as an important element. This is because it needs to be emphasized that the flexibility that comes with conducting case studies does not mean that there are no boundaries of what can be considered 'good' case research. Instead, reflection on the research process should guide the understanding of the findings as well as the strengths and weaknesses of the study. Consequently, the paragraphs in this section will present some of my reflections on the study in this thesis. Furthermore, Dubois and Gibbert (2010) emphasize the importance of transparency with regard to the interplay between the method, theory and case, i.e. in terms of my research process, the matching of the theoretical framework and case and the methodological choices made gave credibility to the study. Thus, my overall intention with this method chapter was to show the reader the research process I have been through as close to its reality as possible without making it too complex. As Dubois and Gibbert (2010, p. 135) stress: "*a good case study provides a model of reality, not the reality itself.*"

That said, it is time for some reflection. Each choice made in this study has had consequences, some of which should be reflected on further, i.e. the choices made have affected what I have found throughout the study. One of these choices is related to the selection of study objects. As the starting point was taken in technology-based start-ups, the choice was based on several factors, such as my own interest in technical solutions, being in a context of a technical university, and my assumption that it would be interesting to capture interaction processes in business networks by studying industrial firms, due to the complexity of innovation. However, this has resulted in many technical or mixed resource interfaces, as the focal resource was of a technical nature. If I had chosen other types of start-ups, with innovations of a more organizational or intangible nature, such as for example services, I would probably have found other types of connected resource interfaces. This in turn may have directed me to other types of conclusions in the end.

Another issue to reflect on is the drawing of the network boundaries. This is not an easy task, and following Halinen and Törnroos (2005)'s suggestion of letting the research problem guide the boundaries, I can see the problem of relying too much on the focal firms' view of the relationship. The aim of the thesis is to develop an understanding of how start-ups relate to different components in business networks. However, relating to existing components such as resources and other firms in the business network is a process whose outcomes are decided by the activities of not only the start-ups but also other actors in the network. Consequently, as most of the interviews were conducted with the CEOs of the start-ups, it is very much a one-sided view of the relating process. Hence, later on in the study, I saw the need to interview also some counterparts of the start-ups' most crucial relationships. In this case, it might have been of interest to use the network pictures during the interviews with the counterparts and also approach additional actors in the start-ups' networks to explore the concept of friction further. However, as this study will continue for another two and a half years, I will take those reflections with me and also focus on the counterparts' own perceptions of the network or even go one step further and interview the counterparts of the start-up's counterparts.

Another challenge I dealt with throughout the study was the unit of analysis. Should I study the start-up, the business relationships or the resources? When this study started, the focus was on the start-up and its relationships with other actors. The unit of analysis was hence the business relationships and the development of these. However, as time went on, greater focus was put on the actual resources, and the outcome of the study pointed more to the focal resource (or potential innovation) as a unit of analysis. I also assume that the next part of this study, leading to the doctoral thesis, will include the resource as a unit of analysis to study *relating* as a general phenomenon in business networks, i.e. to explore how the resource interaction evolves over time and the effects it has on connected resources. To sum up, this research process has undergone some redirection in the past two and a half years within the frame of the overarching project and has been a bit confusing from time to time. However, this does acknowledge the fact that this certainly has not been an "*off-the-shelf*" process as Maxwell (2012) expresses it.

Now, it is finally time to get familiar with Swedish Algae Factory, Aqua Robur and Mevia.

4. Case description and case analysis

This chapter presents the case descriptions of the three start-ups: Swedish Algae Factory, Aqua Robur and Mevia. As mentioned in the previous chapter, they are all technology based and stem from Chalmers School of Entrepreneurship and are thereby trying to commercialize a technological product. They all also collaborate with external partners to do this. The focus of the case descriptions is thereby on the interactive innovation process, i.e. how the start-ups try to develop application areas together with external partners. Even though they have aspects in common, they are all part of unique innovation processes. This raises context-specific issues that have to be dealt with in specific ways. These three cases are presented to illustrate the complexity as well as the opportunities of working with an interactive innovation process for start-ups.

An analysis is carried out of each case to identify its resource combinations and make their interfaces visible during the work to develop the innovations, i.e. explore which features had to be adapted to embed the focal resource into the three business network settings. Each case analysis ends with a summarizing table of the resource combinations and a discussion on how the resource combinations were carried out in the three business network settings. Consequently, this chapter aims to answer the first research question: How are resources combined in the three business network settings?

4.1 Swedish Algae Factory

"Frankly speaking, we started with an alga at the end of 2012, and during the autumn of 2013 we had no idea what we were actually doing. You are an entrepreneur, and you talk to people and look for opportunities […] It was not until the beginning of 2014 that we were able to start acting, because then we had begun to understand the context."

– CEO of Swedish Algae Factory

Swedish Algae Factory and its product solutions

Swedish Algae Factory (SAF) is a start-up in the cleantech industry that focuses on creating environmentally friendly waste water treatment combined with the production of organic algae biomass and nanoporous silica material. SAF was started in 2012 as a project by two students from Chalmers School of Entrepreneurship (CSE) together with researchers from the University of Gothenburg and its Department of Marine Biology. The project was initially run for one year at the business incubator linked to CSE. The current team running the company consists of one of the original co-founding students from CSE, three algae researchers, one process engineer and three additional board members.

It all started on a polar expedition in 2012 during which two researchers from the University of Gothenburg (GU) found a new type of algae growing on polar ice. These algae have distinctive characteristics suitable for the Nordic countries, specifically the ability to grow at low temperatures and in low light conditions. With regard to this, SAF has developed an algae cultivation system that is both surface and energy efficient and as a result requires less energy to produce the algae. Today, SAF is focusing on creating a business model that includes a circular economic mindset and in which carbon dioxide, nitrogen and phosphorus waste are transformed into valuable products. In May 2017, SAF received the World Wildlife Fund's (WWF) global award 'Climate Solver 2017', dedicated to highlighting sustainable innovations, which means that if the application areas developed from the algae reach an international market they will have a huge benefit for the climate. According to WWF's calculations, SAF's innovation could reduce the emissions of carbon dioxide by 21 million tons per year (WWF, 2017). The type of algae SAF works with belongs to the group diatoms and contains various parts that may be useful in different ways. To understand what kinds of products are suitable for selling, SAF is now testing the algae for several applications with different counterparts.

The first area of use is related to waste water treatment. Algae require nitrogen, phosphorus and carbon dioxide to grow. By growing the algae in waste water, nutrition can be provided to the cultivation system in an environmentally friendly way and, at the same time, the water is cleaned from nutrition. When the harvesting of the algae is completed, the algae biomass can be transformed into, for example, bio-crude oil by exposing it to a high temperature and high pressure. The bio-crude oil is suitable for producing fuel and phosphorus-rich biochar, a charcoal that can contribute to the recycling of phosphorous. Due to their unique characteristics, the algae make it possible to produce biofuel in an energy-efficient way, as they do not need artificial light or heating during cold periods. The nutrition-rich biomass can also be used as an ingredient in fish food. Moreover, the silica shell surrounding the algae can be removed and used in different industrial applications. Since it is a nanoporous material, which is both insulating and anti-reflecting, it can be used in, for example, solar cells and batteries.

Due to its early stage, SAF's business model is still under development, and discussions are being held regarding applications that are suitable from a short- and long-term perspective. The main objective is to develop an algae-based waste water treatment system that also produces algae biomass. Today, there are customers interested in the waste water treatment system, and this has enabled a first demonstration plant at which the algae can grow by cleaning the waste water from a nearby fish farm. The plan is for it to become part of a closed system in which one part's waste becomes another part's material. The idea is to focus on selling the biomass as an ingredient for fish food and to make use of the silica shell in different applications before approaching the bio-crude oil and biochar industry.

Although SAF currently has no paying customers, involving potential customers and other partners at an early stage of the product development has been an important way to evaluate different application areas for the algae and to adapt the algae's characteristics to suit existing user requirements and production processes. By initiating discussions with partners, new knowledge has been gained and some discussions have also ended in closer collaboration. Today, several R&D collaborations are run in parallel to test various applications.

Developing the environmentally friendly waste water treatment system

One of SAF's longest and closest R&D collaborations, which is still running, is with GU. The collaboration has opened up opportunities for SAF to use laboratory equipment that would normally have been hard to access. The two researchers who found the algae in 2012 both work at GU, and they started to conduct tests on the algae already back then with regard to algae cultivation techniques. GU is the one developing the material (i.e. the algae), which SAF in turn is trying to market and pass on to other collaboration partners for testing and development of applications. In 2015, the researchers at GU were able to use a greenhouse located in an inner courtyard in the Botanic Garden in Gothenburg to study the absorption of nutrition and how fast the algae grow. By measuring how much nitrogen and phosphorus the algae contain and knowing how fast they grow it was possible to understand how much nitrogen and phosphorus the algae absorb. Using different laboratory equipment, such as spectrometry, it was also conceivable to measure the amount of nitrogen and phosphorus in the water. With this as a starting point, the production process of the algae could be adapted to the desired growth rate.

The research at GU required access to wastewater. SAF therefore turned to Renova Group (hereafter Renova), a waste management company that works with waste and recycling in western Sweden. As the water cleaning process is becoming more costly and it is not possible to send the water to the municipality for cleaning, Renova saw an opportunity to develop an alternative way to clean its water. SAF and Renova teamed up in a project sponsored by Vinnova (Sweden's Innovation Agency) that allowed SAF to use the waste water from the municipality to conduct the tests in the Botanic Garden. As a result, SAF was able to use the water free while testing the suitability of the algae for use as a waste water treatment system for municipalities. However, the tests showed that the nutrition content of the waste water fluctuated too much. On some days, the nutrition level was high and on others it was significantly lower, which aggravated the testing. As time went on and discussions were held on where to use the water treatment system, SAF looked at the fish industry and at cleaning fish water. The water used at fish farms has a constant high level of nutrition, and since the water comes from the ocean, it is obviously saltwater. Hence, it became clear that the focus should be on cultivating saltwater algae and not freshwater algae. In parallel with developing the waste water treatment system, SAF investigated the use of the algae biomass.

Developing the biomass applications

SAF established R&D collaboration with Preem, Sweden's largest fuel company with sales of petrol, diesel, fuel oil and lubricating oil, back in 2014. The project was also supported by Vinnova and included Imperial College London as a third party. The project aimed to evaluate whether the bio-crude oil developed from the algae biomass could be used in Preem's refineries and hence if it would be possible to transform the bio-crude oil into more useful products such as diesel and plastics. During this project, SAF and Imperial College London came up with results for the composition of the bio-crude oil, which they presented to Preem. By looking at the composition, Preem could confirm that SAF’s product was of interest and that there was a possibility that diesel and plastics could be produced from the bio-crude oil. Furthermore, Preem gave valuable feedback on the need to reduce the amount of nitrogen in the bio-crude oil. As a consequence, SAF changed its production process at GU by adding one extra step that extracted the proteins in the bio-crude oil, thus lowering the nitrogen level.

SAF’s intention with this project was to develop a biomass application and build a customer relationship with Preem. By selling the bio-crude oil to Preem, the oil company would be able to produce diesel and other products in a more environmentally friendly way than with the current refining processes. Even though Preem proved it could handle SAF’s bio-crude oil in its existing plants, Preem had no intention of continuing the R&D collaboration with SAF and, as a result, the relationship with Preem was gradually dissolved. However, the results from the project were promising and can be used as guidance for future R&D collaboration with other potential customers and, to date, SAF is discussing what can be learnt from this collaboration. There are still conversation with Imperial College London on conducting more tests in the future. The CEO of SAF expressed the following thought regarding the ended R&D collaboration: *“When I entered this project I was probably a bit naive and thought that of course everyone wants to invest in a renewable future, with SAF providing the renewable part and the oil companies seeing it as important. But I could see that they didn’t want to take the risk.”*

Shortly after, an actor in the plastics industry contacted SAF wanting to finance parts of the coming demonstration plant with the aim of becoming a future customer of the bio-crude oil. The actor saw a necessity in using renewable material in its production of plastic and the importance of supporting start-up companies in the industry by, for example, financing a demonstration plant. Meetings were held between SAF and the company to discuss how long-term collaboration could be carried out. Unfortunately, SAF’s contact stopped working at the company. There was also a risk that SAF could be tied as a supplier to a company that focused on pressing prices rather than building long-lasting buyer-supplier relationships. Since the biomass was not its most urgent application, SAF decided to end the discussions.

As time went on, the focus changed again to developing a nutrient-rich algae biomass that not only recycled phosphorus but also produced omega-3-rich oil through its chemical reactions. During 2016, SAF gradually moved away from the oil and plastics industry and started to look into other application areas such as ingredients for fish food and antibiotics. The start-up initiated discussions with two actors that were willing to buy the biomass as an ingredient for fish food, but not until the demonstration plant was up and running. A third actor was interested in creating medical drugs from some of the peptides found in the biomass. Regarding the latter, a researcher at GU was also involved in testing the application. A fourth actor saw the possibility of using the biomass in fertilizer products, as the amount of phosphor is very suitable for use on farmland. All these initiatives were welcomed by SAF, however, the same situation arose as with Preem, namely, the need for the partners to see a demonstration plant and outputs before investing. For SAF, it was seen as a catch-22, with no investment implying no demonstration plant and hence no products to sell. No products to sell in turn meant no investment. One way to deal with this was therefore to focus on the silica shell and sell silica products from the demonstration plant to make it commercial and attractive to investors. From here on, the focus was on trying to develop the silica shell application to gain some much-needed income.

Developing the silica application

SAF started to contact actors early on to test different applications for the silica that surrounds the biomass and constitutes 20 % of the algae. The silica contains three layers of nanopores, each with its own nanopore size, and the nanopores are interwoven through channels in which essential nutrition and light are transported to the algae cell. It is known that this material is unique and has a high strength-to-weight ratio. It is also insulating and anti-reflecting and hence difficult and costly to synthesize in laboratories. These characteristics naturally opened up possibilities for a number of different industrial applications.

In 2015, a company located in France tested the possibility of using the silica shell in batteries. However, as the silica shell contains oxide, the company had difficulty proceeding with the tests. Neither the company nor SAF had the resources to find a third actor that could remove the oxide. Nonetheless, SAF could take the knowledge of having a good material with high capacity and environmentally friendly characteristics to future collaborations. In parallel, a second actor within chromography wanted to test the possibility of using it as a material in its equipment. However, the company required not only secured production of the silica but also certain characteristics of the silica in terms of uniformity. At this point, this was something SAF could not achieve and hence the discussions came to nothing.

Another application was related to cosmetics, with one actor being keen on buying a finished material but not wanting to take part in the development process. In this case, SAF already had the ability to achieve the quantities of silica that were required but at that time SAF's internal vision put a spanner in the works. As the CEO said: *"We have to feel comfortable with what we are doing. As we have said before, our foundation has always been the 'save the world' perspective, and you don't save the world by using cosmetics."* Instead, the personal view navigated SAF towards the application of energy efficiency and use of the silica in solar cells and thermal insulation.

In late 2015, after reading an article in *Nature* that implied that the use of silica shell on solar cells could increase their efficiency by 30 %, SAF contacted a solar cell company in Sweden. After presenting the silica, the company was positive to starting testing of the product by sending material and discussing how the material could be applied to the solar cells. Tests related to the newly found application were also conducted in parallel at GU. The results were promising and showed that it is possible to put a layer of silica on solar cells, but this needs to be verified by independent tests. Meetings between SAF and GU were and still are being held weekly to discuss the progress of the tests. An electricity company later also showed interest in the silica, and tests were planned on their solar cells. These tests are still running and if they turn out well, the company may be a possible future customer. However, before testing the material on the existing solar cells, the electricity company wants to see it working on a smaller scale. Tests are therefore being conducted in parallel at the Research Institute of Sweden (SP) in Stockholm.

Another relevant application area, which stemmed from the idea of using the silica on solar cells, is thermal insulation. SAF contacted Chalmers University of Technology and learnt that this was a possible application area and certainly a larger market than that of solar cells. The plan was to get a positive response from the researchers and to conduct tests before approaching potential customers. SAF had many irons in the fire and, in parallel with developing the application areas connected to the waste water treatment system, the biomass and silica, the start-up thought about how algae could be produced on a bigger scale and the environmental impact minimized by having a circular economy mindset.

Developing a production facility in Sotenäs and having a circular economy mindset

In the summer of 2015, the industrial symbiosis cluster in Sotenäs started to take shape. By taking the point of departure in the resources connected to the ocean and the marine food industry, the project tried to locate several actors close together that could use the waste water from fish farms as input to produce other products, hence creating a circular production flow. SAF saw an opportunity to be part of this, and in the middle of 2016 most of the prototype facility in the Botanic Garden was moved to Sotenäs.

However, before joining the project in Sotenäs, many discussions were initiated with potential partners to invest in the future demonstration plant. In total, five potential partners were of interest, including one governmental actor; one industrial actor in Denmark, which was also interested in buying the biomass as an ingredient for fish food; and one actor close to the location of Sotenäs. Discussions were also undertaken with two larger actors in the field of automation and control regarding automating the future plant. SAF's strategy was to have five options ready in parallel to open up the opportunity to produce directly when the application areas were set. By doing this it hoped to reduce costs and shorten the time to market for SAF's products.

With regard to the two larger actors connected to automation and control, the plan was to involve them in delivering a system to harvest the algae in the future production plant. However, it proved difficult to involve large corporations in the project. Meetings were held with both actors. Some were constructive and others less so. One problem that arose was the dependence on the contact person. This became apparent when the project stopped due to holidays. The reason for this was the absence of people in the corporation who could shoulder the responsibility.

As time went on, the discussion with the two actors within automation and control dissolved. The plan was now to develop the harvesting technique together with the actor close to Sotenäs. Namely, SAF decided to change to a local actor called AH Automation, which was considered more flexible and able to actually help out with both the harvesting technique and the automation. AH Automation was also conveniently located near Sotenäs, which enabled efficient development of the new harvesting technique as AH Automation could work directly on site.

In 2016, a small demonstration plant, including the algae cultivation, was built next to the company Rena Hav AB's fish farm in Sotenäs. Rena Hav AB wants to use the waste from the fish farm as input for producing biogas. A prototype of a fish farm was also built to which SAF could connect its algae cultivation plant. The demonstration plant consists of a number of shelves stacked on top of each other in a garden house located in the backyard of Rena Hav AB's facility in Sotenäs. This was a good opportunity for SAF to get water to measure the productivity of the algae. Furthermore, 7 grams of silica per week could be harvested and sent to laboratories to evaluate the use of silica shell on solar cells. In connection to this, a master thesis project was initiated at Chalmers University of Technology to design an industrial-scale algae cultivation system (Dankis, 2016). The master thesis project was a result of the plan to expand the fish farm and let SAF use 3000 m^2 on top of the fish farm for its algae cultivation. During this project, both Rena Hav AB and SAF took part in identifying and expressing requirements and prerequisites. As Rena Hav AB already had specifications for the pisciculture project, the master thesis student had to align these with SAF's need for flexibility, due to the ongoing change of application areas. The project led to a suggestion for a new cultivation system for SAF that is flexible and hence adaptable to the different customer requirements that may turn up in the near future. To integrate the algae cultivation system on top of the fish farm, Rena Hav AB will have to install a pump to the fish farm to pump up the waste water to the cultivation. The algae will then clean the waste water from the farm while, at the same time, an evaluation can be made of the attractiveness of SAF as a water cleaning actor. SAF will also extract silica for different applications, and the strategy is therefore to use the test plant as SAF's first commercial plant for silica production. The project resulted in a proposition that is planned to be operationalized in 2018.

The plant will also act as a demonstration plant at which SAF wants to make use of the biomass as an ingredient for fish food to feed the fish at the fish farm by separating the biomass in a nearby biogas plant. Furthermore, the produced bio crude oil will be able to be used in products such as fertilizer and plastic. In this case, the results from the tests with Preem will be of great use. Today, there are two possible scenarios: either the silica shell will turn out to be useful and create validation to attract investors and generate income for future investments in the demonstration plant, or the silica shell will turn out not to be usable in the suggested application areas. This would place demands on SAF to find other application areas, and investments would then need to be made in the waste water treatment system instead. As the CEO of SAF confirmed: *"This is the sticking point at the moment: either we need to find a high-value product or we need to secure waste water treatment production. Or in a dream scenario, we secure really high production and a really large number of high-value products – then it will look really good!"*

Today, half of the week is spent in Sotenäs conducting tests on the demonstration plant and half at GU where laboratory research is carried out on the extraction and use of the silica shell. SAF is heading towards an interesting time and expects to be ready to sell products from the demonstration plant in 2018, while the waste water treatment solution will be ready in 2020 at the earliest. The process of finding users and applications has taken a long time due to the annual verifications of the algae, which are necessary since SAF wants to secure yearly production. Moreover, the biological material puts extra demand on the way this should be done. The long-term perspective on launching products from the algae is something of which the CEO has been very much aware since the beginning. In 2015, she expressed the following thoughts: *"Frankly speaking, we started with an alga at the end of 2012, and in the autumn of 2013 we had no idea of what we were actually doing. You are an entrepreneur, and you talk to people and look for opportunities."* She continued: *"It was not until the beginning of 2014 that we could start acting I would say, because then we had started to understand the context. So, you could say that we have been working with these algae for just one year and four months, and we are very aware of that. As some people made clear to us, 'you won't be on the market for five years'."*

4.2 Analysis of Swedish Algae Factory's interaction in three business network settings

Taking the starting point in the interaction between SAF and the external actors and the process of trying to embed the algae into existing resource collections, it is now of interest to identify those resource combinations and resource interfaces (RI) that have been critical to the development of the algae, i.e. those resource features that need to be adapted. In the analysis below, the algae are occasionally referred to as a 'focal resource' (FR_1), which in turn are combined with other resources (R) in the three business network settings.

4.2.1 Interaction in the developing setting

SAF is working with a number of different actors to develop its product solutions. The trial and error process, which Håkansson and Waluszewski (2007) point out as characteristic of the developing setting, is evident and has shaped the algae's features to approach value also in the using and producing settings. The case shows that GU played an influential role in SAF's early development as it was through this collaboration that SAF gained access to the algae. In 2012, SAF created a business around the algae with the aim of commercializing them. Even though SAF had been created, GU was still involved in the development of the algae. In the beginning, GU could offer what Håkansson and Waluszewski (2002a) refer to as both technical and organizational resources, of which SAF was in great need. The facility and equipment in the Botanic Garden were important to the development of the algae to suit a waste water treatment system. These technical resources, in the shape of a garden house and spectrometry equipment, offered SAF a free opportunity to test the productivity of the algae. Hence, by combining the facility and equipment with the algae and using the organizational resources such as the researchers' prior knowledge of algae cultivation, SAF realized how quickly the algae could grow and how efficiently they were able to clean water. It is important to remember here that an additional technical resource was involved in making this test possible, namely the waste water provided by Renova; see Figure 5. In the technical interface (Dubois & Araujo, 2006) between the algae and the waste water (RI_{FR1-R1}), it became clear that the nutrition levels of the waste water were too unstable, which made it hard to conduct the tests. On the other hand, taking a closer look at the interaction, it is clear that the technical (Dubois & Araujo, 2006) and mixed interfaces (Jahre et al., 2006) between the algae, equipment, garden house and researchers' knowledge functioned well. The resources had features that were easily adapted to the others' features, and the outcome of the resource combinations led to new knowledge about the growth rate of the algae.

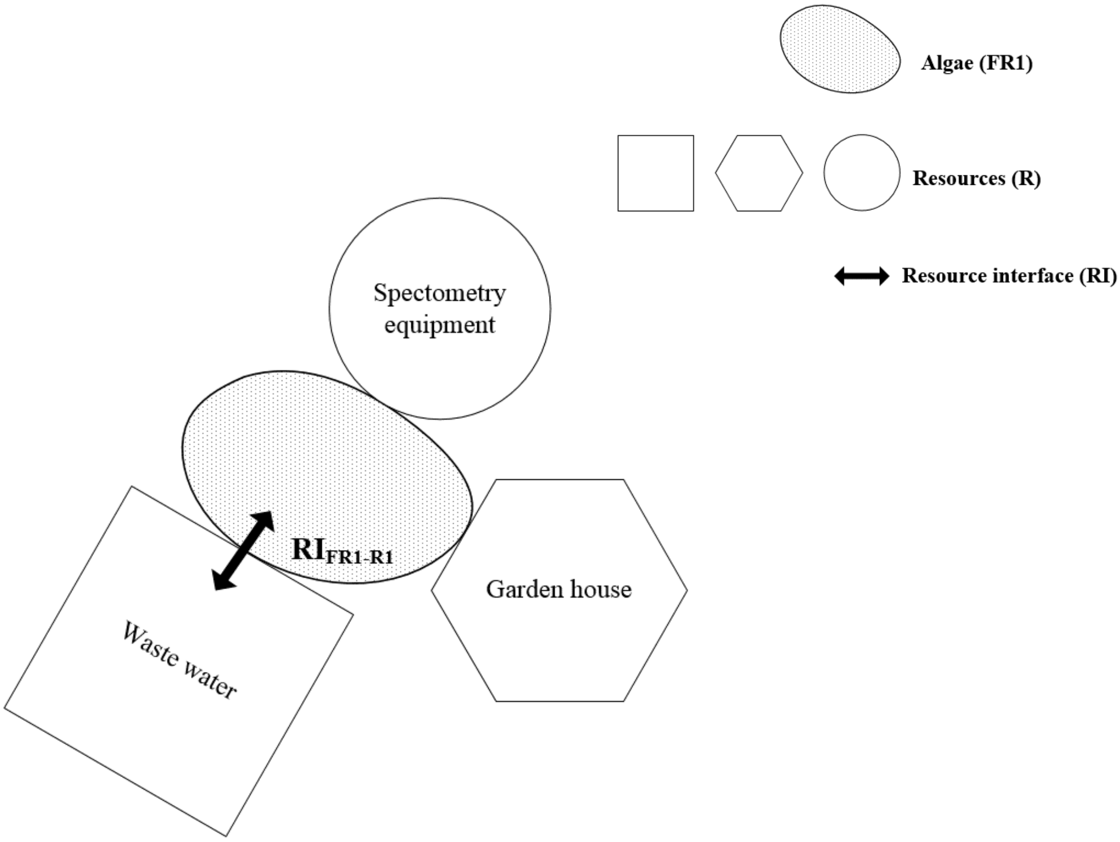


Figure 5. The resource combination between the algae and the waste water

Coming back to the waste water, the technical resource interface between the algae and the water seemed to work well at first, but due to the unstable level of nutrition in the water, SAF had difficulty prolonging the tests. As Gadde et al. (2010) point out, each new resource carries prints of past structures and affects the new resource structure with which it interacts in both a positive and negative sense. The waste water was very much affected by the environment from which it stemmed, and the level of nutrition depended heavily on how the municipality used the water. The difficulty of changing the level of nutrition in the waste water could be seen as a result of heaviness between the resources. Håkansson and Waluszewski (2002b) explain heaviness as a result of resource combination between resources that make up structures of high economic value. In the case of Renova, the economic aspects might have been important, but the thing that really made it hard to change the features of the waste water was the many contact points the waste water had with other resources, such as the inhabitants of the municipality. SAF had no chance of changing all the inhabitants' use of water to fit the composition of the algae nor could it change the feeding routine of the algae. Instead, it was evident that the features of the two technical resources, with regard to the algae and waste water, resulted in what Håkansson and Waluszewski (2002a) denote as friction. The tests helped SAF understand that the algae should be tested in saltwater from fish farms, as the saltwater seemed to have a more stable level of nutrition.

As Ingemansson (2010) emphasizes, an innovation needs to be incorporated with other technical solutions and activities to become valuable. In the case of SAF, it was evident that this required a counterpart that was also willing to make adaptations. By taking part in the industrial symbiosis cluster in Sotenäs, a new opportunity opened up for SAF to combine its algae with existing resource collections at a company called Rena Hav AB. This company was open to integrating the algae into its current resource collection and thus adapt its existing resource collection to enable a better fit between the facility and the algae. This is also in line with previous studies (see eg. La Rocca & Perna, 2014), which stress the importance of mutual adaptions between the resources (and the actors) when it comes to opening up the existing network to new actors.

In this case, Rena Hav AB was developing a pisciculture project in Sotenäs with the aim of using the waste from the fish farm to create energy. SAF’s algae were of great interest when it came to cleaning the waste water. By building a small cultivation plant in a garden house close to the fish farm and then connecting it to the waste water from the fish farm, SAF could see that it worked well to let the algae consume the nutrition in the saltwater. Moreover, a student at Chalmers engaged in designing a potential algae cultivation system for the future test plant, which would give SAF 3000 m^2 of space for cultivation. When the technical resources of the algae and the water from the fish farm were combined with the existing research facilities and knowledge at Chalmers, it became clear that adaptations had to be made at both firms to operationalize the test plant. The technical resource interface (Dubois & Araujo, 2006) between the algae and the fish water worked well as the level of nutrition in the water was no longer unstable. Instead, there was a constant flow of nutrition for the algae. However, the future design required the algae cultivation to be on the roof of the fish farm, and the master thesis student at Chalmers suggested installing a water pump at the fish farm to pump the water up to the roof. The visible technical resource interface (RI_{FR1-R2}) between the algae and the fish farm facility, see Figure 6, revealed features that made it hard to connect it directly to the existing features at the fish farm facility, as the small size of the algae required a large cultivation plant. By adding an extra feature to the fish farm, i.e. the water pump, it was possible to pump the water to the roof and the connected algae cultivation.

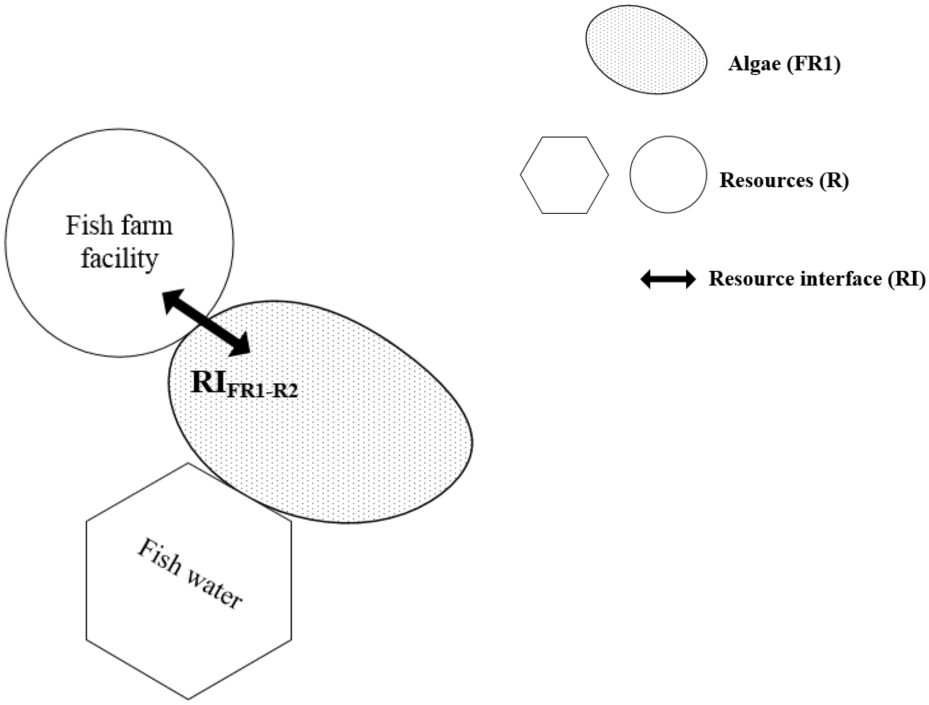


Figure 6. The resource combination between the algae and the fish farm facility

It is not new knowledge that working with potential users and being aware of the user context are highly relevant to start-ups (see eg. Aaboen et al., 2011; Harrison & Waluszewski, 2008; Prahalad & Ramaswamy, 2000). However, by working with Rena Hav AB, SAF saw an opportunity to integrate the algae not only into developing and using contexts but also a future producing context., i.e. it could develop the application areas of the algae by using the waste water from the fish farm as input material to cultivate the algae and also build a harvesting technique directly on site. While the test plant would later turn into a production facility, the biomass could be used as for example input material to the biogas facilities due to be located nearby.

Furthermore, to analyse the possibility of transforming the bio-crude oil developed from the biomass into products such as diesel and plastics, SAF initiated R&D collaboration with Preem. By extracting the biomass from the algae and combining it with technical resources at Preem, such as its refinery, it became clear that the algae were of interest but that their features were not fully compatible with the facility. Contrary to the mutual adaptations taking place between SAF and Rena Hav AB's resource collections, there was great resistance to making adaptations at Preem. One explanation could be related to the discussion of heaviness and the difficulty of breaking existing resource interfaces to open up for new ones (Håkansson & Waluszewski, 2002a). The unique features of Preem's facility, developed over time and in relation to other heavy resources such as the oil, which also influences current settings of production processes, made it hard to disconnect and adapt existing resources to embed the algae's biomass. Instead, the algae had to be adapted to Preem's existing resource collection. On the contrary, Rena Hav AB, which is a smaller and younger company with a less heavy resource structure, saw no problem when it came to being flexible and adapting its own resources to let the algae be part of them.

Coming back to the interaction with Preem, the resource interface between the algae and Preem's facility ($RI_{FR1\text{-}R3}$) revealed a need to adapt the algae to the existing production processes at Preem. With additional knowledge from the researcher at Imperial College London, SAF understood that it had to modify a feature of the algae, namely lowering the level of nitrogen, which required SAF to change its production process at GU ($RI_{FR1\text{-}R4}$); see Figure 7. The production process had to add a step to extract the proteins in the bio-crude oil before it could be transformed in the refinery. Even though the interface between the algae and the facility became smoother and the algae's features were adapted, Preem saw no incentives in continuing the R&D collaboration, and it was therefore hard to match the organizational resources at SAF and Preem. However, SAF was able to use the results when approaching other potential users of the biomass.

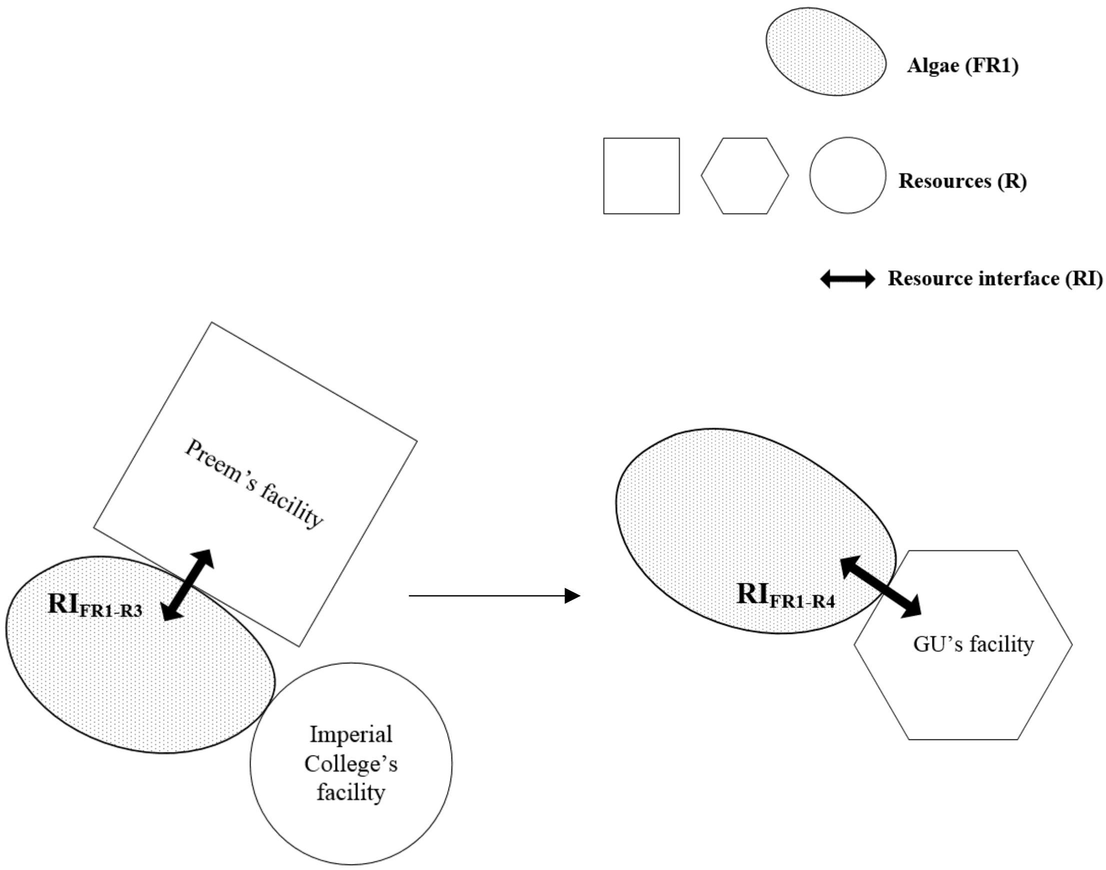


Figure 7. The resource combinations between the algae and Preem's facility and the algae and GU's facility

When the R&D collaboration with Preem ended, a number of different application areas for the biomass were evaluated. SAF's strategy could be seen as what Laage-Hellman et al. (2017b) refer to as working with parallel tracks. SAF approached a number of different actors with the aim of developing several application areas at the same time. One actor in the plastics industry started to show interest in investing in forthcoming demonstration plants, but the discussion soon fizzled out due to a lack of interest on both sides. SAF also investigated the use of the omega-3 encapsulated in the biomass, but here too the discussions ended due to the absence of running production.

Instead of continuing to focus on developing biomass, the application focus turned to developing the silica shell to generate income to finance a demonstration plant. By combining the algae with resources at a facility connected to a company in France, tests were conducted to see if the silica shell was a good component in batteries. The technical resource interface (Dubois & Araujo, 2006) revealed features of the algae that were not in line with the battery, namely the silica surrounding the algae contained too much oxide and hence it required a third actor to remove the oxide. The resource interface ($RI_{FR1\text{-}R5}$), see Figure 8, revealed a feature of the algae of which SAF was not even aware. The level of oxide had not showed up as a problem before. Hence, it required SAF to adapt the algae to fit into the French company's resource collection. Unfortunately, neither SAF nor the developing partner in France was able to make this adjustment itself or engage a third actor. As a result the R&D collaboration ended.

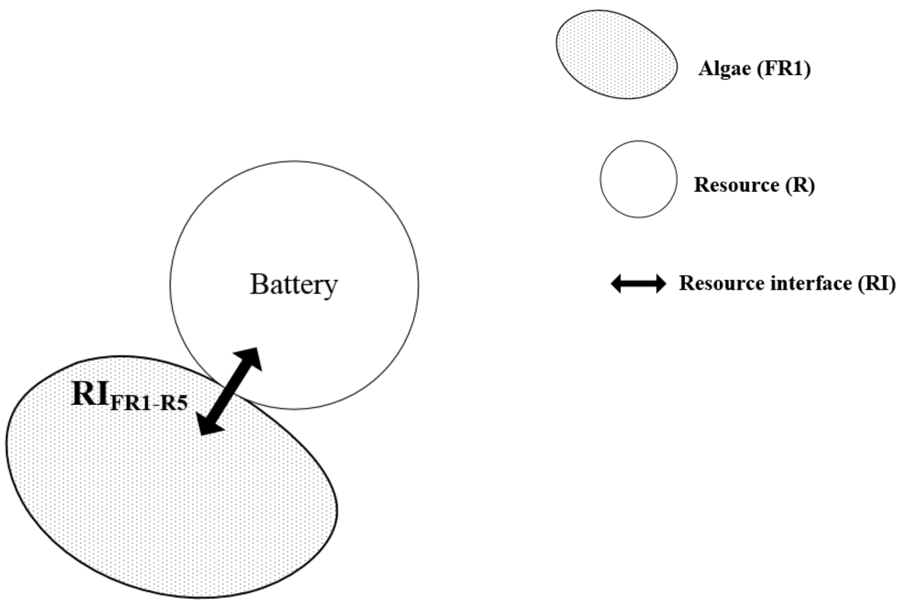


Figure 8. The resource combination between the algae and the battery

In 2015, SAF changed direction and moved into energy efficiency. The start-up came into contact with a solar cell company that was interested in testing the product. In parallel, the silica shell was tested in the laboratory at GU by putting the silica shell on the solar cell and measuring light absorption. The test results were good and could be used when approaching solar cell companies. One electricity company also wanted to test if the silica shell could be used on its solar cells to generate electricity more efficiently.

Each interaction between the algae and the other resources in the developing setting revealed features that either were valuable directly in the resource combination or, as was usually the case, had to be adapted. As Gadde and Håkansson (1993) point out, not all new resources may fit at first, some may need to be shaped to fit the common puzzle. Thus, each new confrontation between the algae and the other resources could be seen as a valuable lesson in which the algae were gradually shaped in relation to the other resources with the aim of becoming valuable in other companies' resource collections, not only in the developing setting but also in the producing and using settings.

4.2.2 Interaction in the producing setting

As pointed out by Ingemansson and Waluszewski (2009), the producing setting is where the patent or prototype is transformed into a product or process. It was necessary for SAF to interact with several partners at the same time to be able to embed the algae into a production context. The reason for this was that it needed to get ready for production as soon as the application areas were confirmed by tests. This is in line with Ragatz et al. (1997), who also point out reduced product development cost and time to market as crucial reasons for engaging suppliers early on. As SAF needed a flexible harvesting technique because it was unsure of which application area to focus on, it had to work with actors that could also easily deliver this. SAF approached both large corporations and local actors, the latter of which turned out to be more interesting. The required flexibility was hard to achieve with well-established companies due to the heaviness of their existing resource collections. Changing their production processes quickly would be costly and affect other ongoing processes within the firms. Instead, the focus was on approaching a smaller supplier called AH Automation.

4.2.3 Interaction in the using setting

As mentioned before, collaborating with potential users or customers is seen as important for start-ups to create an understanding of what the customer is willing to buy (Blank, 2013;

Laage-Hellman, Lind, & Perna, 2014). SAF started to approach potential users early on, but being a start-up with a rather radical idea made it hard for SAF to find potential users and customers that were willing to invest money and time in it. In SAF's case, four actors were willing to buy the omega-3-rich oil as an ingredient for fish food, create antibiotics from some peptides and use the biomass in fertilizer products, but as none of them was willing to invest time and money in a future demonstration plant or development projects, SAF could not guarantee the production rate of the biomass and no actual business relationships were created. With regard to the cosmetics actor, SAF had the opportunity to deliver the amount of silica that the actor required, but due to visionary differences SAF did not want to sell material for cosmetics at that point in time. The logic of idea structure and active structure as well as their interplay (Håkansson & Waluszewski, 2002a) may raise the question of a reverse logic in which the active structure allowed the idea (of using silica in cosmetics) to fit into the existing resource structure at the cosmetics company. However, the vision in itself was absent at SAF. This approach of having a clear opportunity to develop an application area but initially turning it down may be viewed as controversial, as finding a suitable application for the silica was a priority. However, emphasizing an approach to focus on environmental issues and sustainable energy solutions was considered more important at that particular time.

4.2.4 Resource combinations in the three business network settings

In the above analysis, it is clear that SAF works with a number of different actors in parallel to develop and find users and producers for the applications of the algae. Due to the innovative state of SAF's product solution, a large number of the interactions occur in the developing setting. That is, it is difficult to find paying customers and initiating collaboration with suppliers of material for production before confirming the actual area of use of the product. The reason is that the buying customer in the using setting wants to see a functioning product before actually buying it. It was clear during SAF's first years that this could be seen as a catch-22, with SAF reaching out to potential users with the aim of adapting the algae and developing the production of the algae to fit into the user's resource collections. However, since the companies were not willing to invest money and time in testing the product solution, SAF had no chance of embedding it into the existing resource structures. No buying customer means no income to support the development of the demonstration plant to evaluate the efficiency of production. Even though no resource combinations are visible in the using and producing settings today, SAF has had and still does have fruitful R&D collaborations in the developing setting to verify applications.

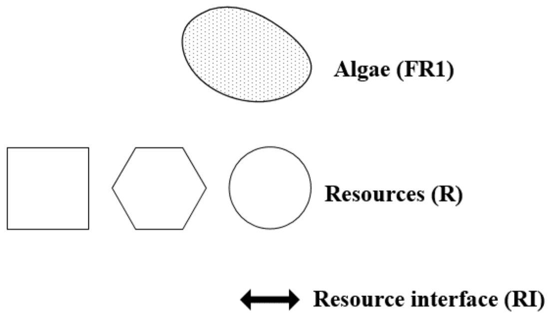
In the developing setting, a number of R&D collaborations have been initiated, and they have often shown results that imply a need for adaptation of SAF's algae. The resource combinations have helped SAF to understand the features of the algae and their impact on trying to fit the algae into existing resource constellations. Even if a majority of the resource interaction resulted in friction between the resources, SAF could still use the knowledge and results from the tests. It was also clear that each friction led to either adaptation of features within the business relationship or redirection in terms of the application area or collaboration partner. Looking at the technical interface (Dubois & Araujo, 2006) between the algae and Renova's waste water ($RI_{FR1\text{-}R1}$), it was clear that the feature of too high level of nutrition in the water led to a redirection for SAF. The start-up changed from using fresh water to trying saltwater. This in turn led to the idea of using fish water and letting the algae cultivate in a fish farm facility. However, in the technical interface between the algae and the fish farm facility ($RI_{FR1\text{-}R2}$), a number of features needed adaptation. As the algae are small in size, a large cultivation plant is required to reach profitable output. This in turn requires the algae cultivation plant to be located on the roof of the fish farm to provide enough space. As a result, the fish farm needs to add a new feature to the forthcoming facility in terms of a water pump to pump the water up to the roof.

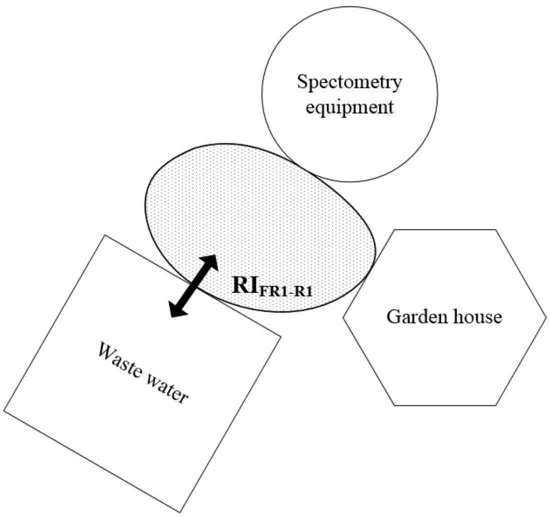
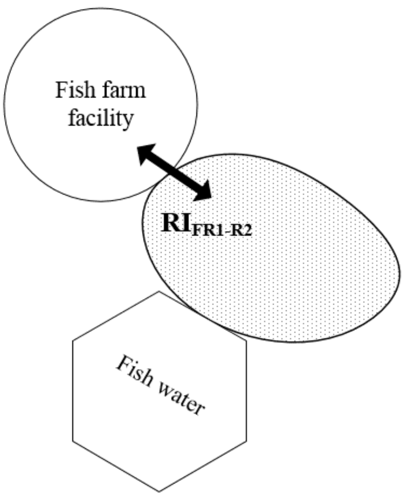
When trying to develop the biomass, SAF also initiated collaboration with Preem. The technical interface (Dubois & Araujo, 2006) between the algae and Preem's facility ($RI_{FR1\text{-}R3}$) revealed that the level of nitrogen was too high in the biomass, which in turn demanded changes to the features of the interface between the algae and GU's facility ($RI_{FR1\text{-}R4}$), i.e. removing the nitrogen required new production processes. At this point, the difficulty in the interfaces could be overcome by adaptation and changes of collaboration partners. However, when it came to the technical interface between the algae and the battery ($RI_{FR1\text{-}R5}$), it was more difficult. Removing the oxide required a third party, a relationship which neither the collaborator in France nor SAF was able to initiate.

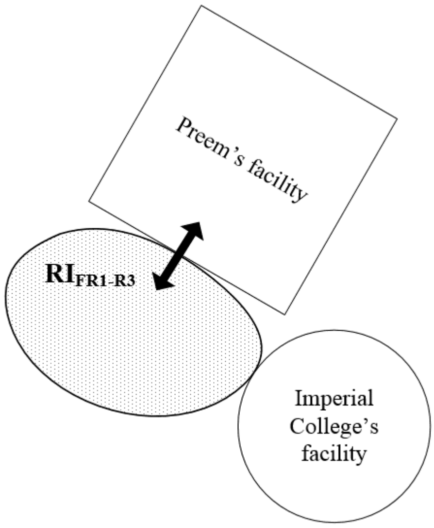
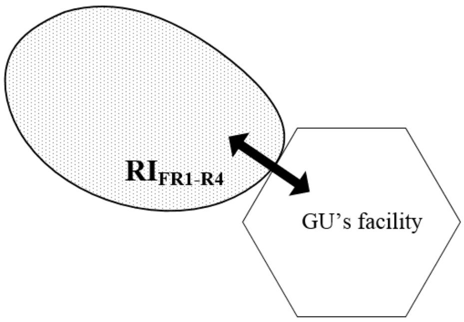
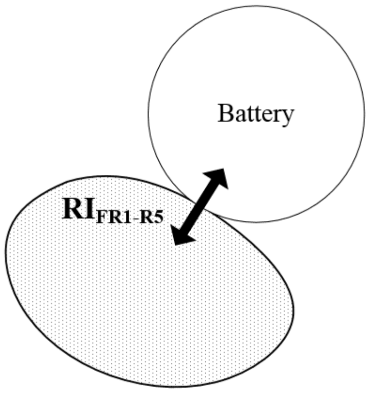
As can be seen in the previous analysis, the algae have to be adapted to existing resource collections, and looking at the using setting, this is where the missing piece is. It is not possible at this early stage just to take the existing algae and expect them to fit directly into the customers' existing resource collections. This is also visible in the producing setting, where, for example, the large corporations had difficulty engaging in the development project of the harvesting technique. Instead, SAF turned to smaller companies that were willing to be flexible and to work on SAF's terms.

However, the difficulty of becoming embedded in the using and producing settings slowly changed as SAF approached an important milestone in its history, i.e. taking part in the Sotenäs project and setting up the first demonstration plant. At this point, SAF had an opportunity to find not only a developing partner but also a potential user and supplier in the company Rena Hav AB. The idea is that Rena Hav AB both uses the algae for the water cleaning process and supplies the algae cultivation with waste water. The test plant will also enable greater production of the biomass, which, at a later stage, can attract potential buyers within fish feed, fertilizer products and medical drugs. In parallel, more tests will be conducted on the use of the silica shell on solar cells and thermal insulation, which could also result in the first income for SAF. With income from the test plant, new investments can be made and validity shown to potential investors, customers and suppliers. Table 4, on the next page, illustrates the five resource combinations discussed in the previous analysis and their outcomes.

Table 4. The identified resource combinations between the algae and other resources.



Resource combinations	Interfaces	Features	Consequences
	**($RI_{FR1\text{-}R1}$)** Algae (FR_1) Renova's waste water (R_1)	Level of nutrition in the waste water	Changing from fresh water to saltwater as Renova could not adapt the level of nutrition
	**($RI_{FR1\text{-}R2}$)** Algae (FR_1) Fish farm facility (R_2)	Size of algae Transferring the water upwards	The algae required a large cultivation plant to reach productivity Adding an extra feature in the fish farm facility, i.e. a water pump

	**($RI_{FR1\text{-}R3}$)** Algae (FR_1) Preem's facility (R_3)	High level of nitrogen in the biomass	Leading to changes in ($RI_{FR1\text{-}R4}$) The relationship with Preem ended Good results to show future collaboration partners
	**($RI_{FR1\text{-}R4}$)** Algae (FR_1) GU's production process (R_4)		Removing the nitrogen in the biomass by adding an extra step in the production at GU
	**($RI_{FR1\text{-}R5}$)** Algae (FR_1) Battery (R_5)	Level of oxide in the silica shell is too high	Could not remove the oxide, but other results of tests confirmed the silica shell as a good material for batteries

As seen above, and in line with Håkansson and Waluszewski (2007), the algae have been dependent on their connections to other resources to become useful. As part of finding suitable application areas for the algae, they had to be adapted in a number of different ways in relation to other resources. The algae could be regarded as a resource with high versatility (Holmen, 2001), with the majority of the adaptations being a result of modifications. That is, the features of the algae themselves usually had to be changed, such as reducing the level of nitrogen and removing the oxide in the biomass. However, it is clear that they also had to be combined with new resources, such as saltwater, to become useful in connection to the development of the waste water application.

4.3 Aqua Robur

"The major reflection is how hard it is to sell innovations. Even products and services that we (being entrepreneurs and engineering students) perceive slightly innovative in comparison to what we want to achieve are hard to convince customers to invest into. The reasons can be old habits or relationships"

– CEO of Aqua Robur[3]

Introduction

Aqua Robur Technologies AB (hereafter Aqua Robur) is a spin-off in the cleantech and hydropower industry that focuses on developing a turbine technology used in water pipes to convert energy into electricity. The company started as a project in 2014 as part of the education at Chalmers School of Entrepreneurship (CSE), and today it is located at Chalmers Venture, a business incubator connected to Chalmers University of Technology.

The technology that Aqua Robur is developing and hoping to commercialize is a result of the need to identify leakages in the urban water supply pipe network. Today, 20-25 % of the fresh water is lost as a result of leakages in the pipelines, and to detect the leakages wireless measurement systems need to be installed all over the pipe network. However, the technology to supply electricity to these measurement systems is expensive and unpractical. Aqua Robur's product solution, an urban micro hydro system called Aqua Power Shark, enables measurement even without access to electricity, by converting a small amount of the water flow in the pipes into electrical energy through Aqua Robur's developed micro turbines.

Today, pilot tests are being conducted in Sweden together with a development partner, and potential user, in the water industry in order to validate the technology. The company is also having encouraging dialogs with additional potential users located around Europe.

[3] Extract from learning journal written by the CEO while a student at Chalmers School of Entrepreneurship in 2014

Founding of the company

As mentioned before, Aqua Robur started as a project in September 2014 as part of the master programme Chalmers School of Entrepreneurship (CSE). The second year of the two-year programme includes running a project at the incubator connected to CSE when the students are put together with inventors from academia, corporations or an independent context. The aim of the Aqua Robur project was to commercialize the idea of using turbines to convert water power into electricity. In the beginning of the project, the team consisted of three students, Niklas Johansson, Pablo Bardossy and Liisa Karttunen, as well as three inventors, Björn Kristiansen, Erik Lagerström and Torbjörn Skånberg.

The inventors are all students from Chalmers, and their idea of using turbines to convert water power into electricity was inspired by Volvo Penta and its boat engine technology. To facilitate the product development of the turbines, the three inventors started a company together, and in 2013 they patented their idea. However, they did not patent a prototype but parameters that fulfilled the future product solution. As the inventors had limited time to work on the idea, they decided to turn to Chalmers and its incubator for help. In spring 2014, they presented the idea to the students at CSE.

During the presentation, Niklas, Pablo and Liisa found the idea very interesting, especially as it came with a patent, and after being put together in a team they began to contact potential investors and customers. As mentioned before, the original technology was intended for use in conventional hydropower plants located in small and natural water streams. The intention was to approach private owners of small hydropower plants in rural areas. In the first half of the year, a number of discussions with external actors were initiated, and the team understood that not only potential customers and investors were of interest but also regulators. To sell the product solution to companies within the segment connected to conventional hydropower, however, Aqua Robur needed to comply with certain regulations from the county administrative board. Operating in natural water streams does create certain limitations due to the specific environment in which the hydropower plant is located.

In the beginning of 2015, this potential customer segment gradually resolved. As time went on, the focus turned to the urban water infrastructure and a customer segment that included water companies owned by the municipality. The application area changed from generating electricity in natural water streams to generating electricity from closed urban water supply pipe networks. This was done by using the overpressure, and hence the water power, created through the different altitudes in the cities. As a consequence, the damaging overpressure in the pipes could also be reduced. Subsequently, the impact from the county administrative board was reduced. On the other hand, the urban water supply pipe network consists of drinking water, which leads to requirements from the Swedish Food Agency. Hence, it was important that all parts in Aqua Robur's product solution were in line with the Swedish Food Agency's requirements on which substances are allowed to interact with food.

During the second half of the first year as a project, the product application changed once more. It went from focusing on extracting energy by reducing overpressure in the water pipes to extracting as little energy as possible, just enough to supply measurement equipment located in remote places with electricity. By doing this, the turbines could also be used in flatter areas and not only in cities with large differences in altitudes.

In spring 2015, when Aqua Robur was still located at CSE's incubator, the team took help from two master thesis students from the Department of Mechanical Engineering. The students, Martin Holm and Philip Angervall, played an important role in the development of the turbine and worked actively to create technical solutions that met the potential users' requirements. The project left CSE's incubator in summer 2015, and Niklas (CEO) was then the only person employed full time in the company. Pablo and Liisa moved from Gothenburg and because of the distance and the financial situation of the project, it was not possible to employ them. At this time, having three business developers was not the main priority. However, as time went on, Martin Holm was employed as CTO with the aim of leading the development process of the product. In September 2015, Aqua Robur was incorporated, and the company now has a third employee, Alexander Ohm to strengthen the product development team. The company's three employees, including the founder from CSE, all have a background in business development and mechanical engineering. Furthermore, the company has a board consisting of the three inventors as well as the two board members Håkan Axelsson and Gunnar Färnström.

Today, the product solution is still working towards the same application area as in late spring 2015, i.e. supplying measurement devices fitted to water pipes with electricity supplied using a micro turbine. Figure 9 illustrates the turbine and generator developed by Aqua Robur. The turbine is installed in water pipes and connected to a battery that stores electricity for the measurement devices. Aqua Robur's turbine and generator are one-third of the complete package, which will probably be sold directly to the sewage companies through measurement device companies.

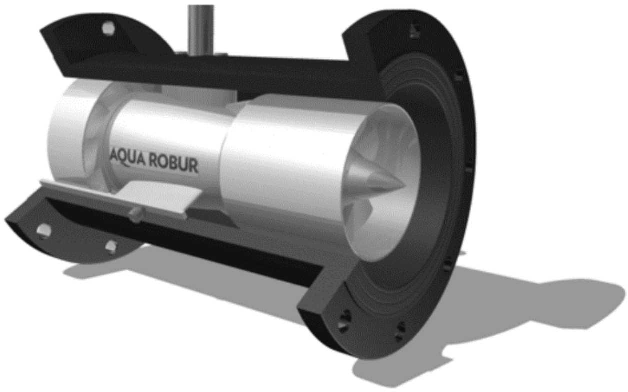


Figure 9. The turbine and generator. Source: Aqua Robur[4]

The future looks promising, as the market to collect data from infrastructure systems is growing and the demand for appropriate power sources for these systems is high. In five years, Aqua Robur wants to be well established on the Swedish market and perceived as the given choice when it comes to flow-based energy sources within water systems. The team also wants to start expanding into Scandinavia and other countries in Europe. The start-up will then focus on building relationships with distributors and other partners throughout Europe.

From idea to first-generation prototype

At the very beginning of this journey, the three inventors became inspired by the thought of using rain power to produce electricity in a sustainable way. They realized that in cities like Gothenburg, with high rainfall, there must be an opportunity to use rain power to light up cities. They transferred this idea to the context of natural water streams and considered the possibility of using motion energy in natural water streams and making electricity from this instead of letting it go to waste. To do this, they realized that it was possible to produce cheap turbines that could produce an even amount of electricity regardless of the water flow. The inventors then turned to Volvo Penta and its propeller technology for inspiration. A boat engine uses existing chemical energy such as petrol and converts it into mechanical energy and finally kinetic energy. As a result, the boat moves. In contrast, the turbine uses the kinetic energy in water flows and converts it into mechanical energy. Later on, the mechanical energy is turned into electrical energy through a generator. A turbine works like

[4] From Aqua Robur's presentation material

a boat engine in reverse. The specific turbine developed by Björn, Erik and Torbjörn could extract 10-100 kW and was suitable for small water streams and the water power they produced. The product, which they called Power Shark, was taken to Chalmers School of Entrepreneurship in August 2014.

Niklas, Pablo and Liisa took on the task of building a business around the product and started by taking initial contact with potential customers. During this time, the application was aimed for use with conventional hydropower and natural water streams and targeted at customers such as private owners of small hydropower plants in rural areas. The aim was to find a site to carry out technology verification. Even though it was important for Aqua Robur to get customer feedback at an early stage to understand the customer requirements, the team realized the need to put effort into networking with other actors in cleantech and the hydropower industry. By doing this, the team became acquainted with the regulatory standards that were likely to impact on the implementation of the product later on. Aqua Robur got in touch with the county administrative board to understand the legal processes and difficulties of operating in such an environment. The team concluded that this potential market could be considered a dead end and that it needed to re-evaluate its strategy.

By the end of 2014, Aqua Robur did not have a clear picture of what it wanted to achieve with the venture. However, it understood the importance of a good industry network and making use of the knowledge of potential customers, competitors and partners. After a meeting with Tommy Ekblad at Kretslopp och Vatten (K&V), a municipal unit that works with water supply and waste handling in Gothenburg, and an inspiring talk with the chairman of the board, Håkan Axelsson, the new venture started to change focus towards water pipelines in cities.

The team began to dig deeper into scenarios in which a turbine could be useful for producing electricity from the motion energy in water. It found the area of community water systems, which in cities like Gothenburg often overflow due to differences in altitudes. When the water reaches low parts in the city, it usually does so with high pressure due to gravity. Sometimes there is so much overpressure that the pipes are close to breaking. To mitigate the risk of breakage, ventilators are put on the pipes to release the energy. By using the turbine, the energy released could instead be converted into electricity and then distributed through the electricity grid. At this time, the higher power range, 10-100 kW, was still appropriate, and the aim was to sell the electricity produced to energy companies such as Göteborg Energi. The energy companies would then act as middlemen by buying the turbines and operating them at the sewage companies.

In parallel with the development of the new application area, initial meetings with potential thesis workers at the Mechanical Engineering Department at Chalmers were initiated. The purpose of this was to make use of other people's knowledge to facilitate the technological development of the new application area. The thesis workers were a good asset since they did not require any payment and could work full time during the spring of 2015 with the aim of developing the first-generation prototype.

Moreover, in November 2014 the team visited the Norwegian University of Technology and Science (NTNU) in Trondheim. The team saw an opportunity to make use of its expertise within hydrology science and use the hydropower laboratory located at the university. Unfortunately, this cooperation ended quite soon after the initial discussions due to the distance. The team perceived it more efficient to stay at home in Gothenburg and use the resources provided there.

After valuable discussions with K&V, Aqua Robur and K&V, together with Älvstranden Utveckling AB and Umeå Energi, put together a Vinnova application – within the programme Utmaningsdriven Innovation – to finance the future tests of the new application. As part of the preparation, Aqua Robur made a visit to K&V's site. Aqua Robur perceived K&V as a potential user of its product and wanted to bring them on board early on in the product development process. Already during their first visit at K&V's laboratory, they could sense the next change of application. The CEO wrote in his learning journal at CSE in week 5, 2015: *"As a part of the preparation to the application and to the customer development process we made a visit to K&V [Kretslopp och Vatten] and one of the sites where they currently have a fix electric installation, a reduction valve and some measurement devices. This scenario is in particular interesting to use since we believe that we can make a good business powering the measurement devices with the turbine"*

The visit to K&V opened up the discussions on whether to start focusing on a new application area within the context of water pipes, i.e. the supply of electricity to the measurement devices located on the water pipes instead of distributing the electricity to energy companies. The main goal was now to get a good response from the board. However, this required Niklas, Pablo and Liisa to provide a joint vision of the product together with real data to strengthen their arguments to convince the board. The team members expressed frustration as the lack of data connected to the new application slowed down the process. The first sign of scepticism towards running the venture after the graduation in May was now visible. The CEO wrote in his learning journal in week 8, 2015: *"Some stumbling discussions on the concept size decision where we don't really have real data to back the discussion with nor have joint vision,"* and he continued: *"[…] I had more visionary mindset whilst Pablo wanted to back our dialog with hard facts, which we currently lack."*

The product development process proceeded with the two master thesis students and Pablo in leading roles to strengthen the arguments to the board. Discussions were held in the team on whether to use an on-grid solution to make use of the overpressure in the pipes and then distribute the electricity to the energy companies, or a considerably smaller turbine, the off-grid solution, the aim of which was to use a smaller power range, 1-10 kW, to supply the measurement devices with electricity. As the CEO wrote in week 12, 2015: *"We have some deep dialog with Håkan [board member] around the future from June and our thought around our possibilities to pursue the project. We still have different visions around the product concept. I see some major risks connected to the on-grid solutions and that business model that P & L [Pablo and Liisa] don't seems to be bothered by."*

Already here, the CEO saw a problem with developing a device that included an on-grid solution. Shortly after this, his concerns were confirmed following meetings with the industry partners Rejlers and Pollex. The dialogues opened the students' eyes to Aqua Robur and gave them an insight into how customers in their industry think and act as well as how companies such as Rejlers and Pollex actually tackle this. In relation to this, the CEO wrote in his learning journal in week 16, 2015: *"The major reflection is how hard it is to sell innovations. Even products and services that we (being entrepreneurs and engineering students) perceive slightly innovative in comparison to what we want to achieve are hard to convince customers to invest into. The reasons can be old habits or relationships"*, and reflected further: *"The large on-grid [solution] has a much higher level of innovation height because of the changes in mindset, investment calculations, work habits and relations they must make. The small off-grid can, on the other hand, apply to the general industry norm of standardized product transactions between supplier and buyer."*

The team faced resistance to a product that it perceived as an innovation that could change and improve the industry. However, trying to change a well-established structure in an industry that already had certain norms and values was not easy. Pablo and Liisa called a number of potential customers the following weeks. More data were collected that strengthened the arguments that the low-hanging fruit had already been taken when it came to the large on-grid solution. On the other hand, the small off-grid solution was much more interesting from a customer perspective.

To understand the potential user's needs and obtain hard facts to present to the board regarding the off-grid solution, Aqua Robur and its thesis students worked closely with K&V in spring 2015. At first, the collaboration consisted of a feedback session in which Aqua Robur asked K&V what it perceived as a good product, knowing that Aqua Robur would go back to its office and think of some new concepts when trying to develop the prototype. The team then showed K&V its new ideas and obtained feedback on certain parameters that needed to change. As time went on, K&V made its facilities available to Aqua Robur. This was a prerequisite for Aqua Robur's future development, as the lack of resources, such as money, made it hard to proceed alone. In March 2015, the prototype tests were initiated for its first idea, the on-grid solution. In K&V's laboratory there is a full-scale water pipe in which Aqua Robur was able to install its turbine and measure how much energy could be converted into electricity. These measurements have since acted as a foundation for the following feedback sessions with K&V. During the collaboration, it became even more evident that Gothenburg needed to measure leakages in a couple of hundred places in the water supply system.

Even though much time was spent establishing good relationships with users and understanding their needs, Aqua Robur considered its future suppliers at an early stage. One contact was established with a supplier of generators located in Kalmar. Aqua Robur preferred approaching small companies that were used to working with start-ups. Initiating contacts with large companies like Siemens or ABB would have made the process complicated and maybe placed Aqua Robur in a situation of dependence. The company in Kalmar performed one-piece production of generators, and the initial idea was to outsource most of the production to the supplier and then have final assembly at the sewage companies. The aim was also to include the supplier in Kalmar in the development process as soon as possible. It was important for Aqua Robur to develop production processes that would suit the future product and collaborate with suppliers that wanted to share the risks.

Going back to the user side and K&V, and the outcome of the tests conducted in spring 2015, it was clear that the on-grid solution was not the right way to go. K&V's only ambition was to provide inhabitants with water. It was not motivated to produce energy and distribute it to the electricity grid to earn extra money. If Aqua Robur were to have invested in developing the on-grid solution, it would have made demands on companies such as K&V to develop closer relationships with energy companies. Questions such as 'Who should own the equipment?' and 'Who will obtain the revenues?' would have been raised, and even though it may sound easy to solve these issues, it is not the main focus of these companies and not a task that can easily be handled. Aqua Robur ended up in discussions on whether to lease the turbines to the energy companies and put the responsibility on the energy companies to operate the turbines at K&V. The feeling was that this could result in complex business models in which the complexity would put a spanner in the works. On the other hand, implementing the off-grid solution would mean investing in reducing leakages and improving the delivery performance of the water, which is also K&V's main mission. As the project leader at K&V explains: *"[…] we have old pipes under the ground which we cannot see that leak. We are therefore building new measurement zones so that we can monitor the water pipe network in a different way. […] I have a project in which we extend the measurement zones with measurement devices and by placing the devices in the soil we are able to measure how much water enters the zone through the pipes and how much leaves the zone."* In other words, the difference in water flow reveals how much water has leaked from the pipes. However, these measurement devices require electricity, and today K&V tries to connect them either to existing power outlets in the city or to batteries. Both ways can cause problems for K&V as the power outlets may be remotely located and the batteries need to be changed after a time.

Finally, in May 2015, Aqua Robur and its board members were convinced to move away from the on-grid solution and instead go for the off-grid one, i.e. using as little energy as possible to produce enough electricity to supply the measurement systems in the water pipe system. By doing this it was possible to also turn to potential users in cities with flats since there was no longer a need to use the overpressure in the pipes. Through the tests with K&V and the discussions with other potential users, customers as well as industrial partners, Aqua Robur decided to meet the users' current requirements instead of creating a problem definition for them. It saw a need to actually adapt to existing industry standards.

Developing the second-generation prototype

Going from the large on-grid solution to the small off-grid one meant rejecting major parts of the first prototype developed in spring 2015. After the summer, the focus was put on developing the second-generation prototype, which meant removing parts of the current technology and giving away the patent. Instead of focusing on a technology push strategy, the start-up changed to market pull and consequently adapted to the users' requirements. The main users were still considered to be the sewage companies, but now there was no need to include the energy companies as potential customers of the turbines. Instead, the idea was to reach out to companies selling the measurement devices to K&V. By using these companies, Aqua Robur could make use of existing relationships between K&V and the supplier of measurement devices. In a wider context, instead of selling the micro turbines directly to 290 municipalities through public procurement, there was now a possibility of selling the product to only a handful of companies. Aqua Robur's intention was to provide the turbines as part of a complete offering sold by the suppliers of measurement devices to public sewage companies such as K&V.

The tests with K&V continued during autumn 2015 with the focus on developing the second-generation prototype, as K&V saw a good opportunity to use the turbine in the future: "*If there is an unlimited amount of electricity, one can transfer [measurement data] more often. So here we have their [Aqua Robur's] product, which is a turbine that can charge this battery. This is a big advantage as we are then able to transfer data more frequently, and we do not need to change battery to the same extent as we do today.*"

By integrating the turbine in K&V's test plant in the water treatment plant in Alelyckan, it was possible to adapt the generator and turbine to be ready for field tests. Today, the test plant is used for testing and calibrating K&V's measurement devices. Using the pipes, Aqua Robur could see how much the pressure in the pipes decreased when it took energy from the water flow and converted it into electricity. The pressure drop needs to be minimized to ensure the water flows at the desired speed. Many of the adaptations that needed to be made were for the size of the turbine and to fit the pipes. Most of the pipes are of a standard size, which allows Aqua Robur to integrate the turbine directly into them. By trying to adapt the turbine to these standard pipes at an early stage, Aqua Robur can later approach other sewage companies without fear of rejection. Furthermore, the generator needed to be adapted to extract the desired electricity level with regard to a low pressure drop. When trying to integrate the turbine with the existing measurement devices at K&V, it was also evident that it could no longer be located directly in the soil. The turbine needed to be close to the device and space for maintenance. This made both K&V and Aqua Robur consider alternative ways of locating the product solution in the water pipe network. K&V started to look for existing wells or zones where the water could be fed from several places. By creating a 'by-pass', K&V could also avoid unnecessary stops. Aqua Robur understood that it required some adaptations from its side as well, so it started to develop a service well to make the turbine flexible to install and maintain.

With regard to the potential buyer of the turbine, Kaktus, no tests have been conducted so far. Instead, the three parties have had discussions together. As the CEO of Aqua Robur clarified: *"We simply need to see how much water flow K&V can provide us with and how much energy we can provide Kaktus's measurement devices with as well as how much measurement data Kaktus can deliver to K&V in the end."*

As well as working with K&V, other sewage companies were approached to gain an understanding of their requirements. In total, discussions were held with 15 different sewage companies, 5 of which on a regular basis. These were located in Gothenburg, Halmstad, Eskilstuna, Stockholm and Helsinki. The idea was to work closely with K&V and then use this collaboration as a reference case when reaching out to other potential users in Sweden and abroad. As the CEO expressed: *"Almost every time I meet someone new, whether it is an end-user or a partner, I learn something new. That's why we have said that it is important to continue meeting new actors."*

Reaching out to new users has also meant running into potential new application areas. One of these was the distance heating sector. At this stage, Aqua Robur weighed up the benefits of focusing on one application area against many. The conclusion was that the water pipe system segment was so large that staying on this track would open up opportunities to sell to a large number of customers. Moreover, by concentrating on one application area, Aqua

Robur would probably also gain concentrated knowledge and valuable feedback. To coordinate several application tracks would just lead to inefficiency in the product development process.

Working with consultants to develop the second-generation prototype

To meet the requirements and make use of the feedback from K&V and hence develop the second-generation prototype connected to the small off-grid solution, Aqua Robur used technical consultants instead of working with large companies. The consultants, often one-man companies, were located in the Gothenburg region and met Aqua Robur in regular meetings. One forum was workshops held at Aqua Robur's office at Chalmers Innovation. Having most of the consultants located in the Gothenburg region was a precondition, as the distance was a major determining factor for Aqua Robur.

During the autumn of 2015, two consultants worked on the mechanical components of the turbine, including constructing the turbine blades and making sure that the turbine did not leak. Two consultants also worked on the turbine's electrical components and hence developed the generator and programmed the microchips aimed at ensuring the charging of the battery. The design of the battery was a major task as it had to be aligned with the measurement devices. The data gathered from the tests with K&V were also visualized in graphs to make them easy to communicate to the stakeholders.

Depending on the type of consultant and his or her previous knowledge, Aqua Robur occasionally gave him or her a freer hand. Sometimes, the consultants already knew what Aqua Robur needed and started to solve the problem without guidance. Other occasions demanded stricter direction from the beginning, with Aqua Robur explaining in detail what it needed and letting the consultants create CAD drawings according to given parameters. Aqua Robur's early phase made itself felt as it required the start-up to consider its developing partners carefully. The consultants working for Aqua Robur were chosen wisely, with many coming from the inventors' own network. As the CEO explained: *"It is really hard to find partners who understand us and newly established firms. It is a bit different to work with us. We have quite limited resources compared with some consultants that are used to sending invoices to Volvo, and they cannot charge us in the same way."*

For Aqua Robur, with its limited resources, it was important to share the risks instead of just ordering jobs occasionally. The intention was to integrate the consultants early on in the development process and later open up the opportunity for more working hours in the future. At the same time, it was not only the consultants' knowledge that was important but also their networks, which could hopefully be used by Aqua Robur later on in the production of the prototypes.

Start building supplier relationships in connection with the second-generation prototype

With regard to the production of the prototype, Aqua Robur's aim was to build its own supplier network for the turbine. The two other parts, the measurement device and the wireless data transfer unit, would be produced by the device manufacturers. All three parts would then be assembled and sold to the sewage companies through the measurement device companies. The start-up did not see the necessity of using the same suppliers as the measurement device companies, instead it focused on finding relevant suppliers located as close as possible to Aqua Robur's office in Gothenburg. The reason for this was the need for flexibility, as the prototype was still under development and Aqua Robur therefore needed to have frequent contact with the suppliers. Even though it was extremely important to find suppliers with which Aqua Robur could build strong and long-lasting relationships, the start-up was now in a phase in which it reached out to several different producers of prototypes. Building a single prototype did not place demands on creating a few long-lasting relationships, as opposed to when it is finished and part of serial production. It was therefore hard to strike a balance between, on one hand, creating relationships with suppliers that wanted to share the risks of the development process and hence open the door to further collaboration and, on the other, keep a distance to be able to change supplier if the prototype changed.

Finding suitable suppliers among conventional manufacturing companies put demands on Aqua Robur to work professionally. These suppliers expected a customer that knew about supply chain management and not as the CEO put it "*a hippie*" entering meetings with wild and crazy suggestions. Aqua Robur had to work hard to fit into the industry standard, from both a user and a producer perspective. Operating in a conventional industry sector differs from being, for example, an IT start-up aiming to sell consumer products. Instead of building its own image and promoting an innovation it believes in, Aqua Robur had to reduce the experienced innovation height and hence the risks involved in implementing the product, in both the production processes and the water supply pipe networks. With regard to the latter, it was important to promote a product that could be useful in already stable processes and hence not jeopardize the flow of water to the residents.

Finding suitable partners as a newly established firm was not easy. The relationship with the potential supplier of generators in Kalmar gradually dissolved. The reason for this was twofold. Firstly, the idea of integrating this supplier into the development of the product and hence sharing some of the risks was not of interest from the supplier's point of view. It turned out that the company was only willing to deliver a finished component in the end. Secondly, the type of components on which the supplier was an expert was no longer relevant to the off-grid solution.

Instead, in autumn 2015, Aqua Robur searched for other producers of prototypes, mostly within the automotive industry. These companies mainly worked for Volvo and were located in the Gothenburg region. Even though the actual production of the product was a long way off, Aqua Robur started to contact potential producers. These were traditional 'Gnosjö-företag', i.e. smaller companies located in the specific area of Gnosjö in Sweden, that could potentially both produce and assemble the product solution. The main criterion when reaching out to potential producers was familiarity working with small companies. Nonetheless, with the incident in Kalmar fresh in mind, Aqua Robur did not want to rush into signing contracts before exploring the possibilities and knowing *what* to produce. While conducting the tests with K&V, new insights might be explored that would have an impact on the choice of supplier. At this stage, it was all about matching the partners' different requirements. The CEO expressed the following thought on this: *"[…] we go to the customers with our prototype to attain some requirements. We then approach our developers who say that 'this is probably possible [to develop].' We then ask if this is possible to produce, and the producers reply 'yes if you adjust this and that.' Then we have to go back to the customers and tell them what is possible to deliver. Of course they in turn will have new requirements, so it becomes this nice loop."*

Aqua Robur initiated discussions with companies such as Svensk Elektronikproduktion, which focuses on producing circuit boards. The start-up also began to look for companies in the 3D-printing industry to produce plastic parts for the prototype. These components would probably be produced by injection moulding in future production processes. One of these 3D-printing firms was Acrone, located in the province of Småland. The procedure was standardized, with criteria such as price and delivery time determining if the supplier was given the opportunity to deliver the parts. All the suppliers were small and used to working with small companies, or as the CEO put it: *"birds of a feather stick together."* Moreover, in 2016, the relationship with the supplier in Kalmar was reforged. At this point, it took on the role of developing the coils for the generator to meet the demand of K&V. However, sharing the risks was still not of interest. Instead, as long as Aqua Robur was paying for the service, the supplier would perform the development activities.

4.4 Analysis of Aqua Robur's interaction in three business network settings

The following analysis starts off in the interaction between Aqua Robur and the external actors and the process of trying to embed the turbine into existing resource collections. The aim of the analysis is to identify those resource combinations and resource interfaces (RI) that have been critical to the development of the turbine. In the analysis below, the turbine is sometimes referred to as a 'focal resource' (FR_2), which in turn is combined with other resources (R) in the three business network settings.

4.4.1 Interaction in the developing setting

Aqua Robur's product solution has gone through a number of adaptations to find a suitable application area for the turbine. As the case reveals, the start-up changed from being a market push to a market pull company by letting the turbine adapt to existing industry standards. In the beginning, the aim was for the turbine to produce electricity by being located in natural water streams and to be sold to owners of small hydropower plants. Through discussions with external actors, it became clear that the turbine required features that made it hard for Aqua Robur to integrate the turbine into the rivers. In the developing setting, there was what Laage-Hellman et al. (2017b) refer to as focused product development collaboration with one external actor, namely Kretslopp och Vatten (K&V). As pointed out by Laage-Hellman et al. (2017b), this type of collaboration can be beneficial for the start-up as it is less time-consuming and allows for a deeper understanding of each other's needs. In Aqua Robur's case, it has certainly brought positive aspects but also the issue of limiting the product development process to one specific situation. Aqua Robur therefore held continuous discussions with other sewage companies and hence created a number of alternative modules to fit into a wide range of pipes.

When Aqua Robur got in touch with K&V in late 2014, the start-up began to develop the first-generation prototype of a turbine to generate electricity in closed water pipes. In this case, the same power range level (10-100 kW) as that used in the natural water streams was still relevant, and the idea was to sell the energy produced to Göteborg Energi and later on to also let it buy and operate the turbines at the sewage companies. As Håkansson and Waluszewski (2002a) emphasize, to realize a vision or idea not only requires support but also the possibility of connecting the idea to existing activated resource structures. In this case, the present resource structure required too much investment for the potential partners involved, both economic and relational. In the end, it resulted in a product solution aimed at solving an existing problem at the sewage companies, namely to provide measurement devices with electricity using a small power range (1-10kW). Changing the application area from an on-grid to an off-grid solution resulted in a lower threshold for selling the turbine. Instead of creating a new constellation, including a new business relationship between Göteborg Energi and K&V, it was more convenient to use the existing relationship between the company selling measurement devices and K&V.

Considering the importance of mutual adaptations when opening up the existing network to a new actor (La Rocca & Perna, 2014), it could be perceived a bit contradictory that most of the adaptations were made only by Aqua Robur. However, due to the heavy resource structure, of which the water pipes are part, it is important to point out that changing or disconnecting them in relation to other resources is difficult. The reason for this can be explained by the same mechanisms as those that Håkansson and Waluszewski (2002b) point out regarding the paper pulp industry, i.e. that many resource interfaces are developed over time and embed the water pipes into a stable structure. These pipes are meant to function for a hundred years and are connected to various places in the city. Changing the pipe to suit the prerequisites of an already finished turbine would be too costly and cause too much disruption to the water flow. It was therefore a very important step for Aqua Robur to be able to test and develop the turbine in K&V's water pipes and hence adapt it to the existing standards.

During the test in 2015, the technical interface (Dubois & Araujo, 2006) between the turbine and the water pipe (RI_{FR2-R1}), see Figure 10, revealed a number of features, at both the turbine and the water pipe, that did not fit and needed to be adapted. By combining the turbine and water pipe it became clear that Aqua Robur needed to adapt the turbine to fit the size of the pipe. Thanks to the testing with K&V, Aqua Robur has been able to develop a standard concept that will later also be able to be adapted to other potential users through additional modules. Even though K&V is the only potential user that has signed a deal to participate in field tests, Aqua Robur continuously discusses its needs with other sewages companies. Today, the turbine fits into a number of standardized pipes with different dimensions and materials. The goal is to meet all the demands of the potential users but with as few product variances as possible.

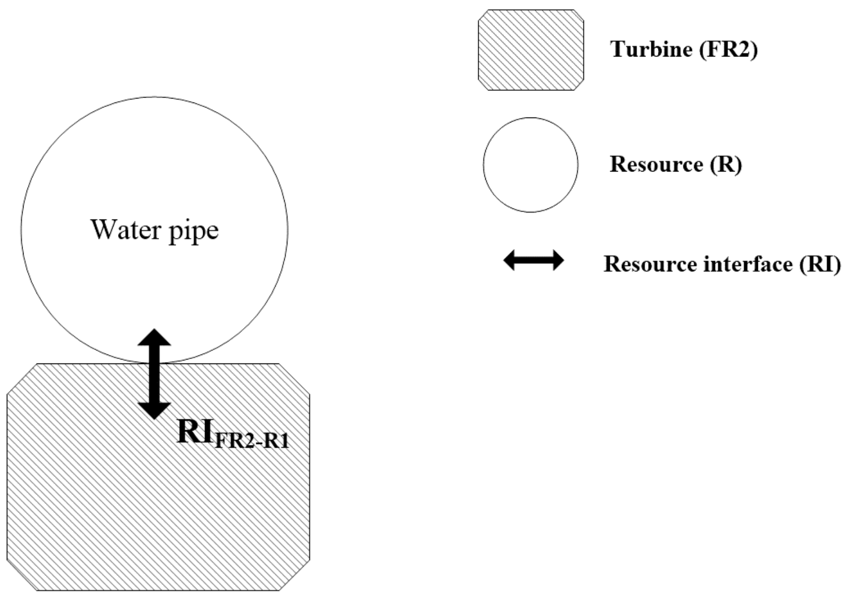


Figure 10. The resource combination between the turbine and the water pipe

When combining the turbine with the pipes, the water flow played an important role in understanding how well the turbine would work. In the technical interface ($RI_{FR2\text{-}R2}$), see Figure 11, between the water, which had a specific flow that had to be maintained for it to reach the consumers, and the turbine, it was clear that the turbine's generator needed to be adapted. This was to avoid pressure drops that were too great when extracting the energy and converting it into electricity, which could result in a water flow rate that was too low. Graphs were made that compiled the data on the extraction of energy and the connected pressure drops and flow rates.

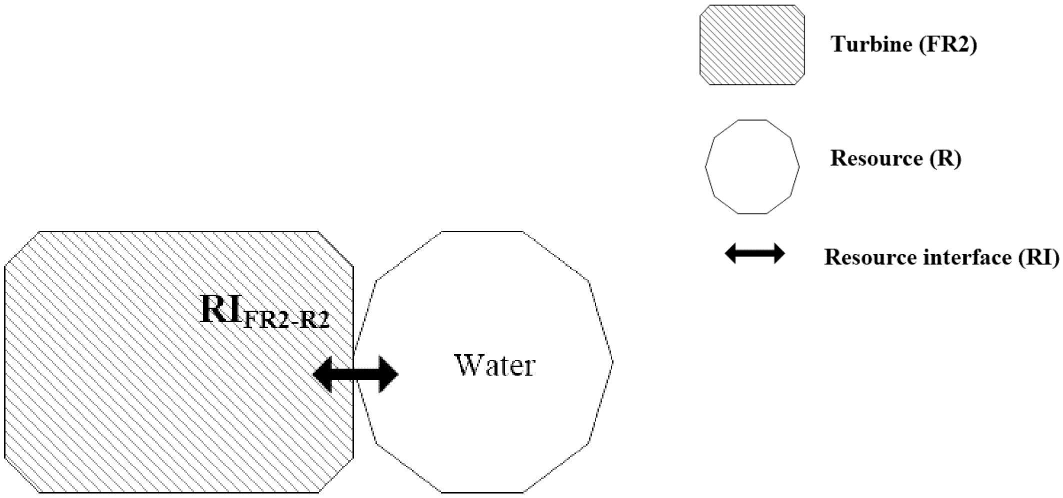


Figure 11. The resource combination between the turbine and the water

Moreover, the turbine needs maintenance and must be located close to the measurement devices. This places demands on K&V to easily reach both the turbine and the measurement devices when the situation requires it. However, today, many of the measurement devices are just buried directly in the soil, which is a challenge for Aqua Robur. In the interaction between the generator (as part of the turbine) and the measurement devices, the technical interface (RI_{FR2-R3}), see Figure 12, revealed a number of features that need to be adapted. As a direct result of the way K&V wants to use the measurement devices, Aqua Robur developed a small service well in which the user can reach the unit. On the other hand, K&V considered the organizational resources (Håkansson & Waluszewski, 2002a) in terms of their working routines and how they could be improved with regard to the implementation of the turbine. It is considered a valuable solution for K&V, since changing a battery requires more work than having a self-sustaining system, like when using the turbine. K&V has therefore investigated whether there are any existing wells for Aqua Robur's product solution to use and how to handle the flow of water when the turbine needs maintenance. As Gadde et al. (2010) emphasize, adding a new resource to existing ones can be difficult, especially when the existing resource collection is heavy and hence not easy to adapt (Håkansson & Waluszewski, 2002a). In this case, there may be a need for an extension of the pipe system to avoid a stop in the original pipe when maintaining the turbine. One idea is to build a 'by-pass' and hence a separate pipe next to the original one that can lead the water when the original pipe is closed. Since this is a rather costly manoeuver, K&V hopes to use the existing wells or insert the turbine in areas where the water is fed with water from several places.

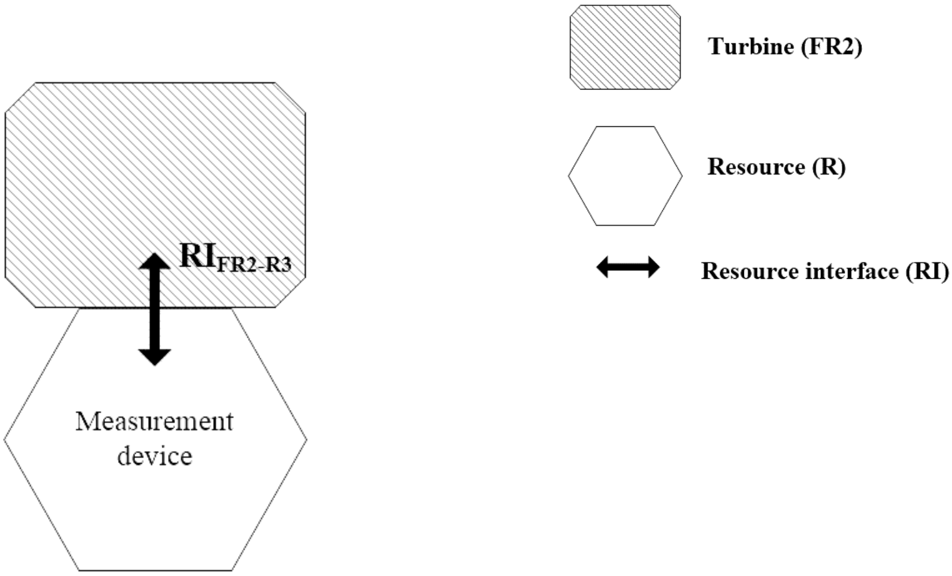


Figure 12. The resource combination between the generator (as part of the turbine) and the measurement device

4.4.2 Interaction in the producing setting

It was not easy for Aqua Robur to involve the suppliers at an early stage and, as Waluszewski (2011) phrases it, to embed the solution into a supplying network. Instead, the start-up had to engage consultants who could be paid per hour and located geographically close to Aqua Robur. One of the first companies that was approached, a producer of generators located in Kalmar, did not want to share the risk at the early stage. As Song and Di Benedetto (2008) emphasize, the start-up can gain much by selecting a supplier that is willing to make financial investments. In Aqua Robur's case, this was exactly what the start-up was looking for: to find someone that was willing to invest in the product development. Due to the setback with Kalmar, Aqua Robur considered being more passive in finding suppliers until a prototype was developed. By working with master thesis workers and consultants, Aqua Robur found a flexible way of developing the turbine, though still costly, as all parts were ordered on demand. When reaching out to 3D-printer companies and other small companies, criteria such as price and fast delivery time were determining factors. However, as time went on and the second prototype started to take shape, it was possible to reach out to the company in Kalmar again. This time it was possible for Aqua Robur to pay the company to develop specific coils to fit the newly developed generator.

It was clear in the technical interface (Dubois & Araujo, 2006) between the generator (as part of the turbine) and the supplier's production facility ($RI_{FR2\text{-}R4}$), see Figure 13, that the supplier needed to adapt and develop new features to be able to produce the new coil. Thanks to the tests with K&V, the generator had now been developed in the way K&V's pipes required, which made it easier for Aqua Robur to reach out to the company in Kalmar again with specific requirements. The coil is one of the few parts that Aqua Robur has decided to develop, with the rest of the material being bought on demand.

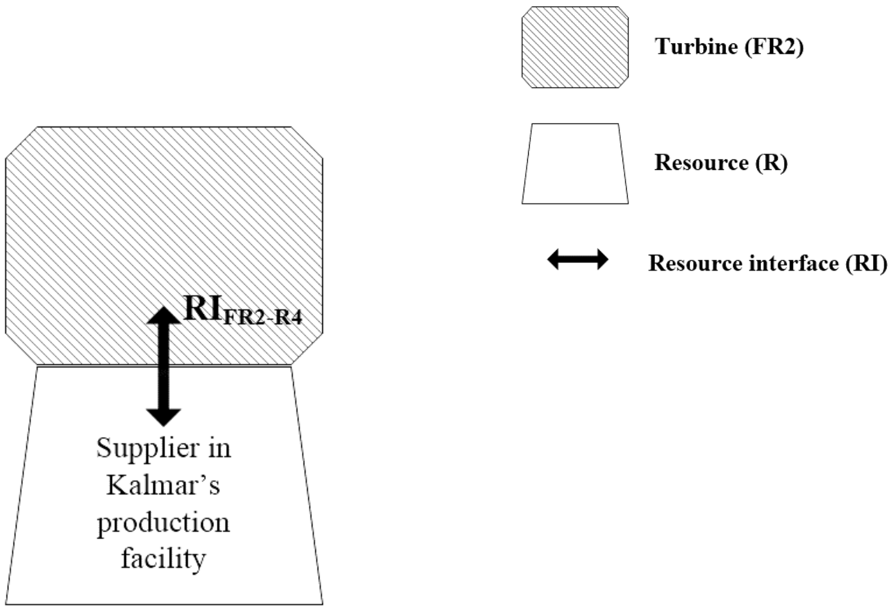


Figure 13. The resource combination between the generator (as part of the turbine) and the production facility in Kalmar

4.4.3 Interaction in the using setting

Working with a potential user, like K&V, already in the developing setting opened up the opportunity to fit the turbine into what Håkansson and Waluszewski (2007) define as a using context, i.e. to make the turbine useful in other production processes or, more specifically, to produce electricity in the water pipe system. In Aqua Robur's case, there is a distinctive difference between the buyers and the users of the turbine. Potential buyers, such as the companies selling measurement devices, are not part of developing the product today. Instead, the focus has been on involving potential users that are already in the developing stage, such as K&V. However, sewage companies such as K&V, and others located in, for example, Halmstad and Helsinki, will not be the buyers of the turbine in the end. In this case, Aqua Robur first tried to build new relationships between the user and potential buyer, as in the case when considering distributing electricity through the electricity grid. Unfortunately, it turned out to be difficult to change an established structure in the context of water pipes. As a result, approaching Göteborg Energi as potential buyer seemed like a dead end. Instead, it was easier to use existing relationships between K&V and the measurement device companies, such as Kaktus. At this stage, when Aqua Robur was testing with K&V, it was therefore important to also meet the requirements of Kaktus, i.e. to understand, during the tests, how much water flow K&V can provide and in turn how much electricity the turbine can generate. Once this is known, it is possible to say how much electricity Aqua Robur can provide to Kaktus's measurement devices.

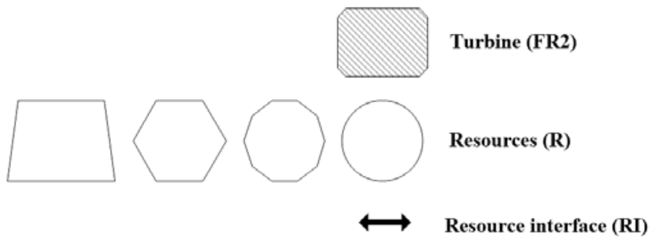
4.4.4 Resource combinations in the three business network settings

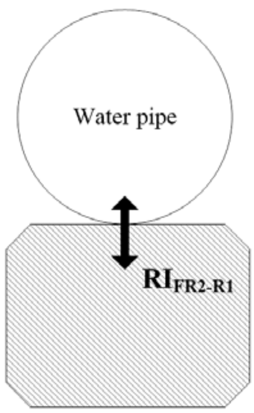
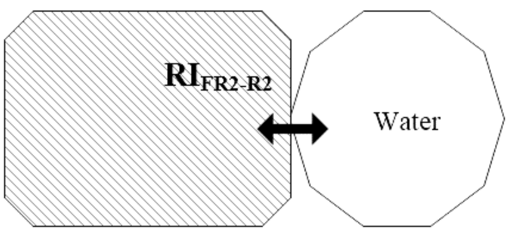
Aqua Robur has been working closely with a potential user already from the beginning, namely K&V. It is also in this business relationship that most of the focal resources, the turbine and the connecting parts have been developed. At this point, Aqua Robur has no paying customer, but it hopes to be a future provider of micro turbines to sewage companies. By getting the opportunity to work with a sewage company in the developing setting and having discussions with other potential users, Aqua Robur was able to develop a standard concept with modules. These were all adapted to the main requirement of measuring leakages in water pipes using water energy and also to each specific pipe dimension.

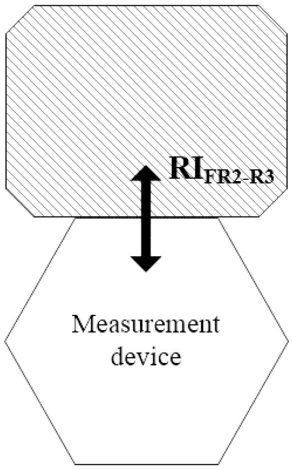
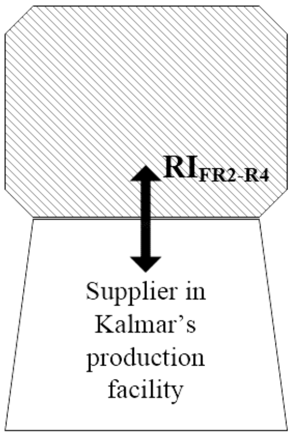
Looking more closely at the interfaces that became apparent between Aqua Robur's resources and those of the counterparts, a focused development process can be seen (Laage-Hellman et al., 2017b). After changing from the first- to the second-generation prototype, the focus was on developing this specific application area. As a result, the number of interfaces has been limited. It has also been important to understand the friction that occurred due to the existing features incorporated into Aqua Robur's and K&V's resources to know what adaptations to make. One example is the technical interface (Dubois & Araujo, 2006) between the turbine and the water pipe (RI_{FR2-R1}) in which the features of the pipe, such as the pipe dimension, led to adaptation of the size of the turbine. As mentioned above, this in turn led to a standard concept used when approaching other sewage companies. This adaptation was rather detached from the other adaptations. However, the technical interfaces between the water (flow) and the turbine (RI_{FR2-R2}), the facility in Kalmar and the generator (RI_{FR2-R4}), and the turbine and the measurement devices (RI_{FR2-R3}) are all connected in one way or another, i.e. the flow of the water had an impact on the amount of energy that could be removed to avoid pressure drops. To be able to extract enough energy to provide the measurement devices with electricity, Aqua Robur turned to the supplier in Kalmar. As the supplier's processes were not adapted to produce the coil that was needed, it started to develop a new type, which it later sold to Aqua Robur. The adaptation of the generator is also closely related to the amount of measurement data required. To integrate the measurement device with the turbine, the two resources also need to be located close to each other. As a result, both Aqua Robur and K&V started to look for possible ways of facilitating access for maintenance.

No resource interfaces are visible in the using setting when it comes to actual buyers of the product. Instead the idea is to approach the customer when the turbine is functioning at the potential user. Buyers such as Kaktus will then sell the total product solution to sewage companies such as K&V. Nonetheless, the meetings with the potential buyer are important to understanding how the measurement devices function. Table 5 below summarizes the four different resource combinations discussed in the previous analysis and their results.

Table 5. The identified resource combinations between the turbine and other resources



Resource combinations	Interfaces	Features	Consequences
	**($RI_{FR2\text{-}R1}$)** Turbine (FR_2) Water pipe (R_1)	The dimensions of the water pipe	Aqua Robur created a standard concept with modules
	**($RI_{FR2\text{-}R2}$)** Turbine (FR_2) Water (R_2)	Flow of the water	Aqua Robur needed to adapt the turbine to avoid pressure drops that were too great, which could result in the flow rate of the water being too low

	**($RI_{FR2\text{-}R3}$)** Turbine (FR_2) Measurement device (R_3)	Today, the measurement devices are located directly in the soil The turbine needs maintenance The amount of measurement data required	Creating a service well to reach the turbine and measurement device Technical adaptations to measurement devices
	**($RI_{FR2\text{-}R4}$)** Generator (FR_2) Supplier in Kalmar's production process (R_4)	The generator needed to be adapted to avoid pressure drops	The coil needed to be adapted and was developed both in house and at the supplier in Kalmar

The analysis reveals a number of adaptations that the turbine had to go through to fit into using and producing contexts. After some redirection of the application areas in the beginning of Aqua Robur's journey, the turbine began to be developed with regard to the specific application of extracting electricity from water flowing in water pipes in the city. The focal resource could be seen as having low versatility (Holmen, 2001), with the focus on just one application area. In this case, most of the adaptations were made with regard to resource combination, i.e. to integrate the turbine into the existing pipes in the city, it first needed to be combined with other resources, resulting in modules. These modules were in turn standardized to fit the water pipes. Furthermore, a service well was combined with the turbine to improve use in the water pipes by providing better access for maintenance.

4.5 Mevia

"As always happens with new technologies, some people have found it amazing and others are a bit more sceptical, but we've found that it definitely helps individuals take their medications better. One individual told us it's impossible to forget his medications now, which is great feedback for us."

– CEO of Mevia[5]

Mevia and its product solution

Mevia is a start-up that focuses on developing intelligent solutions for the health care industry. The start-up was initiated as a project in 2012 by three students from Chalmers School of Entrepreneurship. The project ran for one year as part of the education at the school, with the aim of developing and commercializing a product solution originally designed by Stora Enso, a large Swedish paper manufacturer. The product stemmed from the idea of helping patients take the right dose of medicine at the right time, i.e. to improve patient adherence. Initially, Stora Enso focused on developing an appropriate package for medicines to achieve this objective. However, as the idea reached the school and the project developed, the team saw an opportunity to integrate the package into an IT solution to obtain real time feedback on whether the patient had taken the assigned medicine. After one year as a project at the school of Entrepreneurship, one student left and the project employed one part-time IT developer. In 2015, there were three full-time and two part-time employees. Mevia moved to a science park connected to a university hospital and continued as a project until the summer of 2014, when it was turned into a registered corporation. During this time, the agreement with Stora Enso dissolved. The two companies are still connected through licence agreements, and they share knowledge when they occasionally meet. The network of Stora Enso has also guided Mevia's choice of partners to some extent, mainly on the supplier side. Today, Mevia has three employees and a board consisting of four members. In addition, in 2017 the start-up was chosen as one of the 33 most promising tech start-ups in Sweden (NyTeknik, 2017).

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[5]Source: Pharmaceutical Technology (2017) Tapping digital technologies to improve drug adherence. Retrieved10082017. From http://www.pharmaceutical-technology.com/features/featuretapping-the-internet-to-improve-drug-adherence-5711300/

Mevia’s product solution consists of three parts. The first is the *package*, which has printed conductors that run underneath a blister pack. When the pill is detached from the blister pack the circuit is broken. The package is connected to the second part, a *cellular (GSM) module* that delivers real time information about the removal of the pill, i.e. when the circuit is broken. The third part is the *IT solution*, which receives the real time data. The Application Programming Interface lets the customers choose which information is most relevant to extract according to their needs and displays the observation data from the packages, such as the number of detached pills, package ID and expected pill consumption.

There are two application areas for Mevia’s product solution. Firstly, it is suitable for clinical trials in which correct observation data from patients are critical when trying to evaluate if a drug will make it to the market. By increasing the patient’s compliance with taking the pill and logging when, clinical trials can give a more valid outcome. Secondly, the company is trying to enter the homecare industry, where the product solution can facilitate the treatment of patients. By letting relatives, patients and doctors follow the intake of drugs in real time and sending out reminders to the patients, more effective treatment can be achieved.

Mevia works with other companies to develop the different parts of the product solution, such as the package and IT solution. The basic idea of measuring when the circuit is broken and storing the information is present regardless of the application area. However, each user has his/her own requirements when it comes displaying and using the information. Features such as the print, colour and size of the package are also set according to the user requirements. Moreover, many discussions are initiated with companies and maintained in the hope that they will end in a fruitful exchange.

Developing the smart package together with existing customers

Today, Mevia has no paying customers, but two were previously involved in developing the product. One of these customers was located in the UK and is a supplier to pharmacies that use the package for their medicines. The reason for approaching the UK market at an early stage of the product development was twofold: the pill organizers were suitable for Mevia’s package and the pharmacies had an active role when it came to patient care. For example, they had authority to take out the pills from their original package and place them in specific pill organizers. This routine is forbidden in Sweden, which made it hard for Mevia to approach the Swedish market in the beginning. For more than two years, there has therefore been continuous testing in the UK of Mevia’s package and the related IT solution, which has directed the product solution towards its current characteristics, such as the design of the package.

By testing how Mevia's product solution worked together with the customer's medicine and seeing how appropriate it would be to integrate the solution into the customer's clinical trials, new product features could be developed. One example was the IT system, which needed to be connected between several parties. When the pharmacy (i.e. the end customer) checked a box in its IT system that information had to be sent to Mevia's data storage, which required a number of adaptations between Mevia and the customer. It is important for Mevia to work with a company for which it is possible to follow up and hence make use of customer feedback. However, at one point, Mevia was not able to adapt its product according to the customer's requirements. There was too much noise in the delivered data. Sometimes the messages with the reminders did not reach the user. To solve the technical issues, Mevia had to turn to its supplier to remake the technical parts of the product. Unfortunately, the supplier was not able to solve the issues and as this process took time, the customer in England tired of waiting and prioritized work with another company. Mevia technically serves as a back-up at this time, which means that the customer is not paying for any products.

A packaging company in Canada was also involved in buying and testing Mevia's package solution. This company is also in the smart packaging industry and perceives Mevia's solution as valuable. The company delivered a design for the potential package that Mevia evaluated and commented on. Mevia and the customer then agreed on a product that was suitable for production and met the customer's requirements. In this case, Mevia was a supplier of packages that the customer in Canada used to solder its own electronic parts on. Today, this relationship brings neither money nor feedback to Mevia.

Although Mevia is highly dependent on customer feedback, it had one customer that was just a buyer. That was a market research company located in the UK that buys and tests Mevia's products on behalf of a pharmaceutical company. As the pharmaceutical company changed focus from the US market to the UK market, Mevia also changed market research company from one located in the US to the current one in the UK. The market research company attained the requirements of the pharmaceutical company, reached out to suitable packaging suppliers such as Mevia and tested the function of the product and how it was perceived by its users. If everything turns out well and the pharmaceutical company is pleased with the results, it may end up in a future customer relationship for Mevia. Today, Mevia has direct contact with the end-user, the pharmaceutical company, but no tests are conducted between the two companies. The tests have been a good opportunity to understand the end-user's needs. In an interview with pharmaceutical-technology.com[6] the CEO expressed the following thoughts: *"We are also working on market research studies with the pharmaceutical industry to see if the technology works for certain patient groups. As always happens with new technologies, some people have found it amazing and others are a bit more sceptical, but we've found that it definitely helps individuals take their medications better. One individual told us it's impossible to forget his medications now, which is great feedback for us."*

To find potential customers, Mevia has initiated discussions with and is evaluating a number of different firms in the pharmaceutical industry. These are located in Sweden, the US, the UK, France and Germany. Furthermore, Mevia attends trade shows and conferences to be part of the ongoing discussion in the industry. One example is welfare technology fairs where managers and officials in municipal health care meet. By participating in these fairs, Mevia is able to reach out to future customers and users in the field.

Trying to establish a position on the home health care market

Mevia is also trying to establish a position on the home health care market through different R&D projects. Firstly, with help from Sweden's innovation agency Vinnova, Mevia has been able to initiate R&D collaboration with the Swedish homecare service. Mevia's product has huge potential when it comes to rationalizing the processes within the homecare service. One example is making it easier for the homecare service to observe its patients' intakes of medicine. However, this is a complicated market to enter due to the regulations and number of actors involved. For example, one actor pays for the product and another actually uses it in the end. This demands that the project involve relevant users and buyers already from the beginning.

During this R&D project, Mevia presented its product solution to a retirement home that was able to test the product's function for a few weeks. The tests started in 2014 and involved two workers and a handful of patients living at the retirement home. During the test, the participants had to take sugar pills at certain times during the day. If they missed one and the circuit did not break, they received a reminder in the form of a text message or call. The latter was more convenient for the elderly patients as they did not have mobile phones. The tests were followed by meetings at which Mevia had the chance to obtain feedback on the usage. During these feedback sessions, it became clear that the integration

[6] Source: Pharmaceutical Technology (2017) Tapping digital technologies to improve drug adherence. Retrieved10082017. From http://www.pharmaceutical-technology.com/features/featuretapping-the-internet-to-improve-drug-adherence-5711300/

of the package and the GSM module was hard to manage. As one of the participating nurses explained: *"… there was a small box which should be connected to the package. If you take the pills for more than 14 days you have to change package and also move the box to the next package. It was a bit hard to connect it correctly."* Integrating the GSM module into the new package required precision, and neither the elderly nor the workers managed it properly. Mevia listened to the feedback and modified the shape of the package.

Mevia and the people involved at the retirement home met several times during the test period, and the meetings often focused on the technical areas where Mevia and the retirement home presented errors in the test. Did the test person receive a reminder when he or she missed taking a pill? Did the test person take the pill when the reminder arrived? These meetings were open to the workers as well as the elderly people, which required Mevia to be both clear and pedagogical.

Being part of the tests also placed demands on the workers and the residents of the retirement home. The majority of the workers perceived it as an extra workload, and the elderly people could not see the benefits of participating. Moreover, the technical features presented a threshold to get over. However, the two workers who participated in the first test round were eager to proceed to the next stage of the test, and they are now trying to convince the staff to be part of the next test round. One of the participating nurses clarified this: *"There is always interest in improving and reducing the deviation of forgotten pills. We are only human and if we can get help to reduce the deviations it will be of great interest to us, as it is important that the people who live here get the right medicine at the right time,"* and the nurse continued, *"Science is really interesting, as long as it can contribute in a relatively easy way, as I said, without it taking too much time and effort as everything else has to be done too."*

As another important step in understanding the users' needs, market research projects are being conducted with several actors related to clinical research forums, retirement homes and offices for innovations.

Coming back to the tests with the previous customer in the UK, they inspired Mevia to initiate cooperation with Apoteket AB in Sweden, one of three pharmacies that is allowed to take out pills from their original packages and rearrange them in new ones. The difference compared with the UK is that this is not done directly at the pharmacy but, with special permission from the Swedish food and drug administration, it is allowed in one specific place: Örebro. A specific combination of drugs is put into small bags that can later be picked up at selected pharmacies in Sweden. Using the experience and knowledge gained from the tests in the UK, the threshold for initiating tests with Apoteket AB was lower. The tests had two parts. First, a feasibility test was carried out by 13 seniors over 80 years old in a test environment in Norrköping where the participants are evaluating the service. It turned out that 92 % were willing to pay for the product in the future and most of the feedback was easily taken care of as it was mostly related to easy things.

The second part involved testing Mevia's solution in the home care service in Orust. The home care staff were provided with reminders of when the medicine had to be taken, thus facilitating the visits at the patients' homes. Compared with the retirement home, this working routine had completely different logistics and no permanent IT system to which the reminders could be sent and later distributed. Instead, each staff group (5-10 people) had one phone to which the reminder was sent. It was always a bit unclear who had the phone on a specific day. The person with the phone then had to send the reminder to the person concerned in the group. This extra step caused some displeasure among the staff. However, some saw the benefit of potentially giving the reminder directly to the patient and thus reducing the work load for the home care staff. The latter is where Mevia sees great potential for actual benefit. Letting the end-user (or patient) take the medicine by himself or herself instead of involving the care staff would lead to much more efficient division of work for the home care service. Today, Apoteket AB has started to give out information to its customers about Mevia's product solution as an add-on to Apoteket AB's service of providing customized medicine bags.

All the test results have served as a basis for the coming version of the package, which is planned for release in 2018. The goal is to create a product that is practically impossible to use incorrectly. The package and GSM module should be easy to integrate, and the logging and reminders to take pills should be close to 100 %. As the CEO of Mevia explains: *"We can develop anything from a technical point of view, but then it is also about integrating it into production processes and making it work for the users. If we develop a good app and we think it is good, a ninety-year-old may not agree. So, it is always important to have the users involved in the dialogue [...] in the end, they are the ones buying and using the product. I mean it is not me who will buy and use it…or maybe it is in the long run."*

Producing the smart package by working with a number of different partners

At this point in time, Mevia works with different suppliers to produce the product solution. As it contains different parts, it requires different types of partners such as, for example, printing firms and IT companies. To make the package, Mevia has a supplier that produces the cardboard without the specific circuits and colours. The ordered cardboard is then sent to a printing firm in Sweden that prints the circuits and colours. When it comes to choosing a printing firm, a deliberate decision has been made to approach small firms with less capacity than, for example, the big players such as Billerud or Stora Enso. This is for financial reasons, as the latter would have resulted in greater start-up costs. At the current printing firm, the packages are printed on commission and according to Mevia's requirements. These requirements in turn have been aggregated from the feedback from all the involved users. After printing, the cardboard is sent to another firm in Sweden, close to the printing firm, which punches out the package. This firm frequently also works with the printing firm on other projects. Mevia sets the requirements for the colours and design to use and works with different suppliers when evaluating which colours to use.

Looking specifically at the printing process, Mevia uses a certain printing machine at the printing firm for half a day, two days a week. The head of marketing at the printing firm explained with regard to its weekly operations: *"They [Mevia] have bought hours and booked a time slot every Tuesday and Wednesday […] our staff are of course present at the printing machine, but they [Mevia] are active and take part in helping with the printing process. They then head on to another firm to get it punched and glued."* That is, Mevia is present at the production of the printed packages to see that everything goes according to plan. As the colours conduct electricity, they are developed before going to the printing firm, as the printing firm does not have the ability to develop this special colour itself. However, the printing firm assists with its printing expertise and always has people stationed by the machine. The same machine is also used by Stora Enso, which introduced the printing firm to Mevia. If it turns out that Stora Enso and Mevia print on the same day, they often have informal dialogues to share information on their particular printing processes.

In the printing process at the printing firm, every batch could be perceived as a new test in which the current measures may or may not turn out to be useful. From a technical point of view, it is important to follow up measures of parameters such as conductivity. It is essential that the customers' requirements for, for example, the design of the package are met.

The printing firm sees itself as a partner that helps Mevia develop its product. When Mevia approaches the printing firm with new suggestions, it is willing to adjust its machine to meet the requirements, such as, for example, a new line that has been bought with a dryer that is faster than the original one to make production more efficient. Even though Mevia is considered a small customer and no common plans or forecasts have been developed between the two companies, it is important for the printing firm to be part of this kind of innovative project. As the head of marketing said: *"It is always interesting with new companies and exciting to be involved in new projects. When it eventually hits the market it is always fun to be part of it. This is something we try to do with other companies as well, trying to help develop the product."*

Today, the printing firm is able to produce approximately 10,000 packages per batch with Mevia's current requirements for design, colours and circuits. As Mevia continues to grow and hence plans to produce more packages, it may be necessary to consider adding new producers. For Mevia, choosing a suitable printing firm is about following its instincts. When it comes to the process of printing colours and circuits on cardboard, Mevia can choose from a large number of suppliers. When Mevia wants to test something new, it chooses the supplier it believes in most. Currently, the printing firm in Sweden is frequently hired, but a printing firm in Denmark has also been involved in the printing process. Mevia believes it is important to always be aware of other options, and it has initiated discussions and started working with other printing firms located in Sweden, Denmark, Finland and Eastern Europe. Mevia evaluates the producers to see if they are capable of printing on the cardboard according to the given parameters for the colour, circuit and design. The time perspective is also important when evaluating the firms, as is the ability to develop a good relationship with the printing firm. It is important for Mevia that the printing process, especially when it reaches a high volume per batch, is conducted autonomously.

The product solution's GSM module was previously developed together with an IT company in Finland. This relationship started at the beginning of Mevia's journey, with Mevia deciding on the module's characteristics and the IT company developing the module through coding. Mevia would then test the module to see if it met the requirements. However, this relationship ended when Mevia's requirements could not be met. Instead, collaboration was initiated with a company in Gothenburg. The IT solution system (the Application Programming Interface) is developed by Mevia itself, and the graphics, which are later printed on the cardboard at the printing firms, are developed together with a number of designers, such as students and consulting firms.

In 2016, Mevia initiated collaboration with AERIS, which is a SIM card provider. Since all the data from the package is sent to Mevia's IT system through the telecommunication network, the GSM module must be adapted to fit a SIM card. These are standardized, which means that Mevia can easily change to Telia or any other brand without altering the shape of the module.

4.6 Analysis of Mevia's interaction in three business network settings

The starting point for the following analysis is taken in the interaction between Mevia and the external actors and the procedure of trying to embed the smart package into an existing resource collection. The analysis aims to identify those resource combinations and resource interfaces (RI) that have been critical to the development of the smart package, i.e. the resource features that needed to be adapted. In the analysis below, the smart package is occasionally referred to as a 'focal resource' (FR_3), which in turn is combined with other resources (R) in the three business network settings.

4.6.1 Interaction in the developing setting

At this point in time, Mevia has no paying customers and it works actively on developing additional application areas for the smart package. One of these is the use of the package in the home care market. In the activities conducted with the retirement home, the smart package interacts with several organizational resources, creating so-called mixed interfaces (Jahre et al., 2006). The tests at the retirement home have given Mevia an opportunity to adapt the package to its potential users. From the retirement home's perspective, its organizational resources, in terms of knowledge and routines, caused Mevia to adapt the smart package to fit better into the retirement home's resource collection, i.e. in the mixed interface ($RI_{FR3\text{-}R1}$) between the user's knowledge and the smart package, see Figure 14, the retirement home worked according to previous routines that now collided with the procedures of testing the smart package.

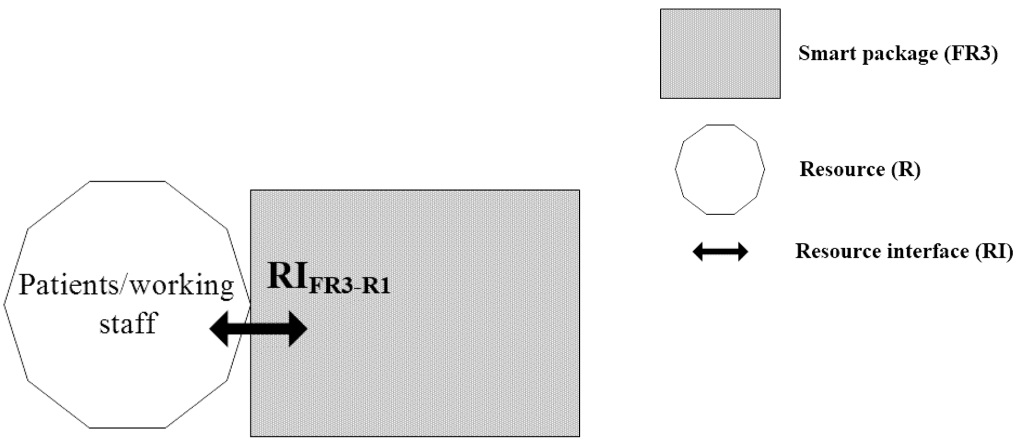


Figure 14. The resource combination between the smart package and the users at the retirement home

As Jahre et al. (2006) point out, the mixed interface is a complex one, but here too value is created, especially with regard to the economic aspect. In Mevia's case, there is definitely economic value in embedding the smart package into organizational structures, as the main users of the package are humans. However, integrating the package into existing working routines was not an easy task. For example, Mevia asked the residents to take a pill at a certain time every day: if they forgot, a reminder would be sent to them. It became clear in the feedback sessions that the residents lacked the technical knowledge and thereby incentive to use a mobile phone for reminders in the form of text messages. Mevia therefore had to change the reminder service to include a phone call to make it easier for the residents to use the product solution. The routines also had to be adapted as the staff and residents needed to participate in regular feedback sessions. This was perceived as an extra workload for the users but did help Mevia to improve the smart package.

The difficulty in the mixed interface between the smart package and the retirement home's routines can be explained by the concept of *heaviness*. Applying this concept to organizational resources may be a bit unconventional, but taking into consideration what Håkansson and Waluszewski (2002a) refer to as "heavy", namely the result of a resource developed in relation to other resources, it can be assumed that the working routines and knowledge at the retirement home have been developed over time in accordance with previous experiences and interaction with other technical and organizational resources such as, for example, the use of technical equipment and habits, which in turn have affected the working and daily routines at the retirement home. This have made it hard for the smart package to be integrated as the existing routines are heavily connected to previous experiences and therefore hard to change.

Moreover, the mixed interfaces between the staff's and the residents' previous knowledge and the package helped to reveal a number of features in the internal technical interface ($RI_{FR3x\text{-}FR3y}$) between the package and the GSM module that did not work together; see Figure 15. It was difficult for the users to put together the GSM module and the new package once the old package was empty. This became clear during the feedback sessions. Mevia then had to go back to its developing partners and suppliers to reshape the features of the smart package, i.e. the technical resources in terms of the GSM module and the package had to be adapted to obtain a well-functioning interface.

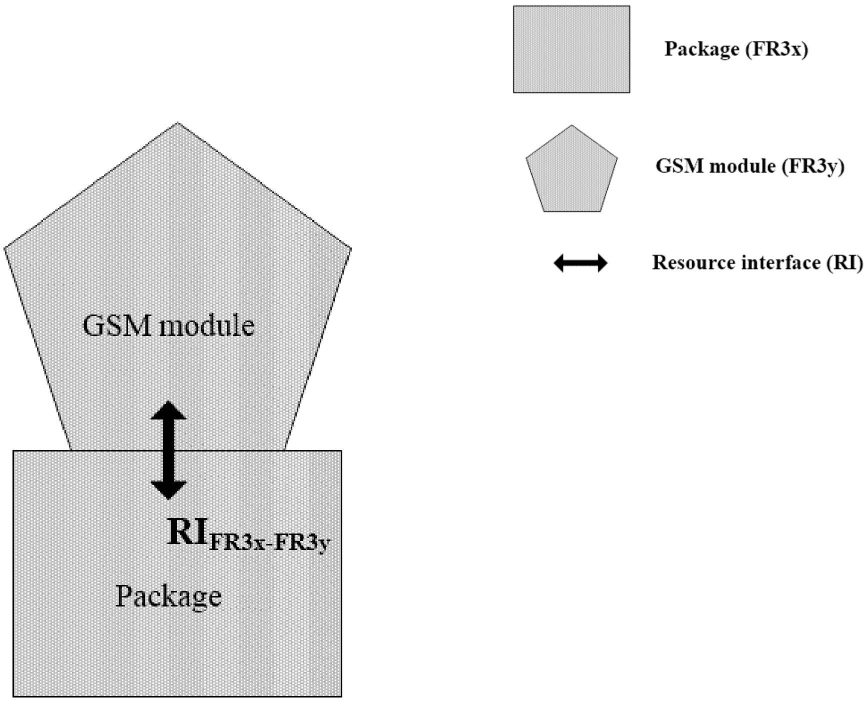


Figure 15. The resource combination between the GSM module and the package

In the collaboration with the home care service in Orust, organizational resources also affected the future adaptations of Mevia's smart package. In this case the mixed interface (Jahre et al., 2006) in terms of working routine at the home care service and the smart package (RI_{FR3-R3}), see Figure 16, revealed features at the home care service when it comes to visit patients efficiently. Due to existing working routines, Mevia understood that it was better to focus on locating the alarm directly with the patients than to let the staff distribute information among themselves.

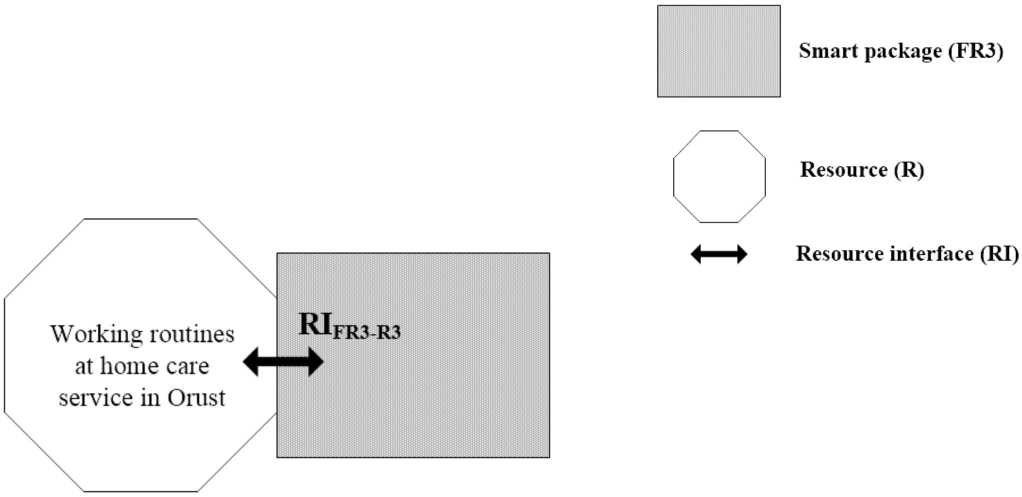


Figure 16. The resource combination between the smart package and the working routines at the home care service in Orust

4.6.2 Interaction in the producing setting

When it comes to producing the parts of the smart package, such as the GSM module and the printed cardboard, Mevia works with a number of suppliers. Some more at arms-length distance and some closer. One of the latter is the printing firm, which has been willing to make adaptations to suit Mevia's requirements. This fits well with Handfield et al. (1999)'s reasoning on the importance of the suppliers' impact on innovating firms. In the interface, see Figure 17, between the technical resources of the cardboard and the printing machine (RI_{FR3-R4}), a number of features were revealed that required both Mevia and the printing firm to change their processes. One feature that has been developed continuously is the conductivity of the colour. This is an important parameter that Mevia develops internally with regard to the way the printed batches turn out. The interface between the cardboard and the printing firm also revealed a feature involving a dryer that was too slow. The printing firm therefore adapted its printing machine to create a more efficient process by buying a new and faster dryer. Another feature at the printing machine involves the number of packages per printed batch. Today, the printing firm can produce 10,000 packages per batch. This is currently enough for Mevia. However, a number of printing firms are available if larger batches are needed.

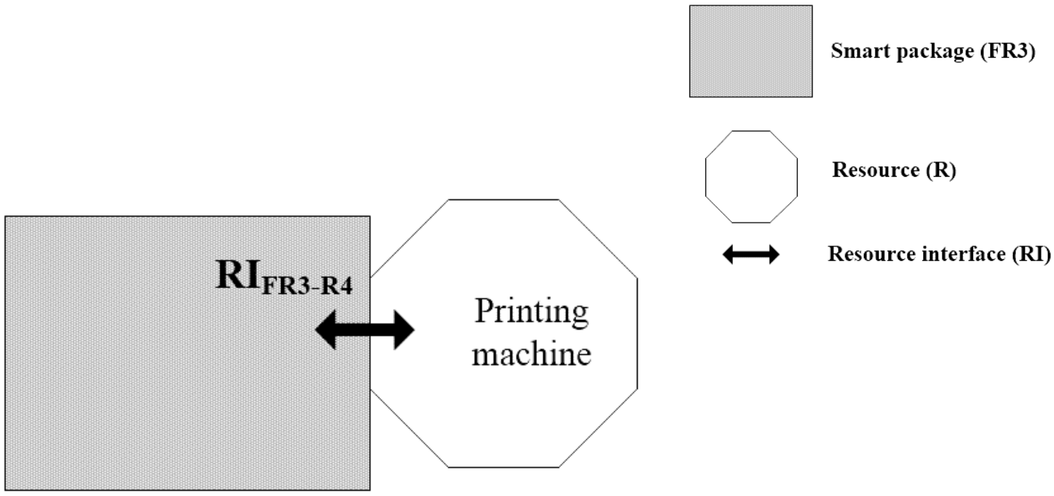


Figure 17. The resource combination between the smart package and the printing machine

4.6.3 Interaction in the using setting

Mevia has had three customers that have paid for the product, two of which were also part of evaluating and developing the solution. As pointed out by Aaboen et al. (2011), the initial customer has a huge influence on the direction of the start-up, and in Mevia's case the previous customers also played an important role when it came to developing the current characteristics of the smart package. Thanks to continuous and fruitful feedback from the users, the function of the package could be shaped and later also used in other areas such as the home care industry.

In the beginning, Mevia was interested in reaching out to the Swedish pharmacy market, but it encountered difficulties when it came to approaching potential buyers. As Mevia's product required the package to be broken and pills taken out of the package, tests could not be carried out in Sweden. The reason for this was the lack of authority to decide over and rearrange the patients' medicine. Mevia therefore turned to the UK market, as the regulations were different. In this case, the pharmacies were able to take out the pills and put them into suitable pill organizers, such as the ones for Mevia's smart package. During the years that followed, a number of tests were conducted, and through these it became clear that the technical parts of the product needed to be modified. For example, there was too much noise in the data in the technical interface (Dubois & Araujo, 2006) between Mevia's and the customer's IT systems ($RI_{FR3\text{-}R5}$); see Figure 18. For example, text messages did not arrive on time and adaptations needed to be made for the IT systems to communicate with each other.

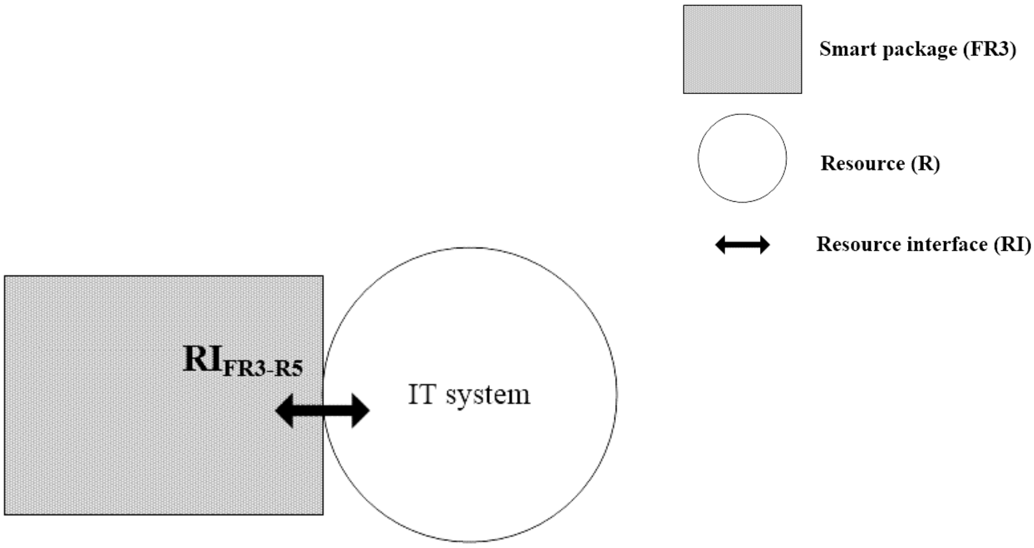


Figure 18. The resource combination between the smart package and the IT system

Even though Mevia's supplier was not able to modify the technical parts of the product, which resulted in an end to the business relationship with the customer in the UK, Mevia could still use the information in the tests with Apoteket AB. It is also evident that Mevia has used other actors, such as the previous customer in Canada, to gain feedback on the shape of the package.

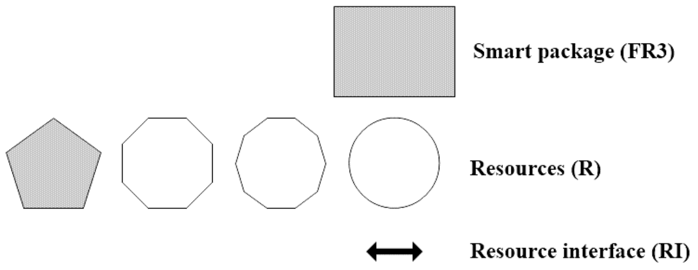
4.6.4 Resource combinations in the three business network settings

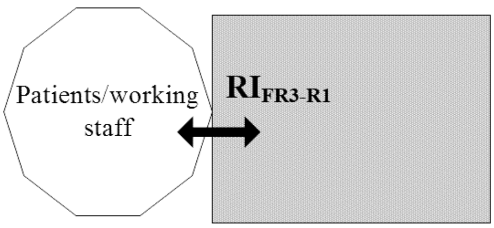
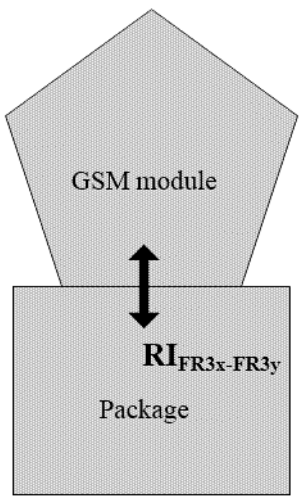
As can be seen in the previous case analysis, Mevia is working on adaptations of resources together with actors in all three settings. Mevia has been able to combine its resource collection in developing, producing and using contexts, which, according to Håkansson and Waluszewski (2007), is a an important step to creating an innovation. The start-up has been able to involve existing as well as potential users in the product development process. Moreover, the printing firm has provided support when it comes to testing the conductivity of the printed packages and been willing to adapt its own resource collection to meet the features of the smart package. Resource interfaces are visible both within the internal resource collection, as for example between the package and the GSM module, and between resource collections. In the developing setting, it is clear that the mixed interfaces (Jahre et al., 2006), (RI_{FR3-R1}) and (RI_{FR3-R3}), between the smart package and different working routines at the potential user's premises, as well as the technical interfaces (Dubois &

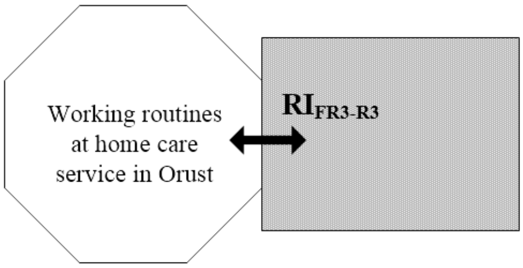
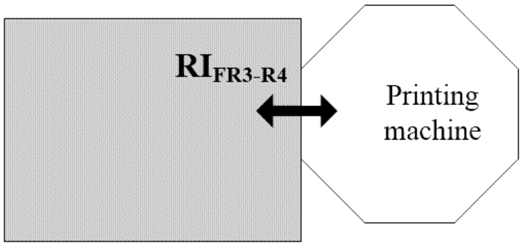
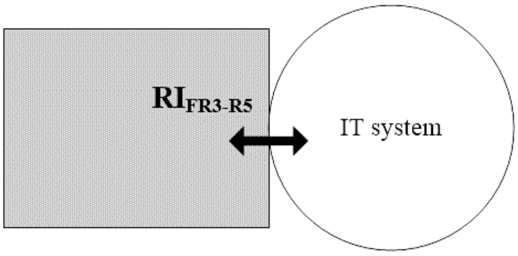
Araujo, 2006) between the smart package's internal resources ($RI_{FR3x-FR3y}$), had features that needed to be adapted with regard to the organizational resources. As this product is aimed for use directly by people, features such as user-friendliness and alignment with previous routines are important. This requires good integration between the parts of the product as well as adaptations to suit the patients' previous experiences. The resource interface (RI_{FR3-R5}) between the IT systems was of a more technical nature, which means that the friction in the interface was due to technical misalignment.

It is also clear that the requirements of existing and potential users affect the relationships with the suppliers. Looking at the printing firm and the technical interface between the cardboard and the printing machine (RI_{FR3-R4}), it was necessary for the printing firm to adapt its processes to meet the requirements of the potential users. Features such as the dryer being too slow and the limited number of products per batch provided sufficient reason for Mevia to start looking for other printing firms. However, the current printing firm was eager to keep Mevia as a customer and therefore willing to modify its machine. The printing firm also expressed a desire to be part of developing innovative products. In the case of the printing firm, it was evident that it was not a particular user's requirement that impacted the adaptations but an aggregated opinion of all the potential users involved. Table 6 summarizes the five resource combinations discussed in the previous analysis and their outcome.

Table 6. The identified resource combinations between the smart package and other resources



Resource combinations	Interfaces	Features	Consequences
	**(RI_{FR3-R1})**Smart package (FR_3) ‘Knowledge/ routines’ (R_1)	The residents had no incentives to use a mobile phone for text messages Old working routines	Mevia had to change the reminder service to include a phone call Led to adaptation in ($RI_{FR3x-FR3y}$)
	**($RI_{FR3x-FR3y}$)** Package (FR_{3x}) GSM module (FR_{3y})	Difficult to integrate the GSM module and package when the pill organizer was empty	Adapted the two parts to make them easier to integrate

	**($RI_{FR3\text{-}R3}$)** Smart package (FR_3) Working routines home care service (R_3)	Problems distributing the information among the workers	Mevia started to consider locating the alarms (text messages) with the patients
	**($RI_{FR3\text{-}R4}$)** Cardboard (FR_3) Printing machine (R_4)	The colour needed to dry faster, but the printing machine's dryer was too slow The printing machine can only print 10,000 packages per batch	The printing firm bought a new dryer to make the drying process more efficient Mevia has many options available to change printing firm if demand requires it
	**($RI_{FR3\text{-}R5}$)** IT system Mevia (FR_3) IT system UK (R_5)	Text messages did not arrive on time	Adaptations between Mevia and the UK Tried to approach the supplier, which failed to deliver The business relationship with the UK dissolved

The previous case analysis shows a number of ways in which the smart package was developed or, in other words, in which the features of the focal resource were adapted to those of other resources (Baraldi & Waluszewski, 2005; Håkansson & Waluszewski, 2007). In the interfaces between the smart package and the other technical and organizational resources, it became clear that to achieve versatility of the focal resource (Holmen, 2001), most of the adaptations had to be made due to modifications, i.e. the internal features of the smart package had to be adapted to integrate the smart package into a using context and a producing context. Features such as a better interface between the parts of the smart package and changing the reminders to fit the users' previous experience were all a result of confronting the smart package with external resources in the three settings.

5. Analysis of connected resource interfaces

In the previous case analysis, each start-up's interaction pattern was analysed in each of the business network settings. By taking the starting point in the three business network settings, the analysis could reveal a number of technical interfaces (Dubois & Araujo, 2006) and mixed interfaces (Jahre et al., 2006) between the focal resources: the algae, turbine and smart package, and other resources. Evidently, all three start-ups have visible resource interfaces in the developing setting. No matter how far into the commercialization process the start-up is, it works actively on developing either existing application areas or new ones.

In the case of Mevia, it has come far in embedding its focal resource in all three settings. It is also interesting to note that it is the only start-up that has been able to attract paying customers at this point and that its most significant developed interfaces are results of a mix of both technical and organizational resources (Jahre et al., 2006). The retirement home's previous knowledge and working routines were vital to understanding how the features of the interface between the GSM module and package should be developed. In contrast, the application area of Aqua Robur's innovation is of a more technical nature in the sense that it will not be used directly by people but operated in the pipes. This also reflected which interfaces were developed between the turbine and other resources. The turbine's (and connected generator's) interfaces were developed between two technical resources (Dubois & Araujo, 2006) belonging to either the developing or the producing setting. It was also evident that most of the interfaces became visible between Aqua Robur and one specific actor, namely K&V. Furthermore, in SAF's case, most of the emerging interfaces were located in the developing setting. In contrast to Aqua Robur, which only developed one application area with one actor, SAF developed at least five application areas with different actors. This could be seen as what Laage-Hellman et al. (2017b) refer to as "broad" product development, which also led to a number of different interfaces between SAF's algae and other actors' resources. In this case, one of the most noteworthy interfaces was actually not related to the resources of the algae or other technical resources but to organizational resources (Dubois & Araujo, 2006) belonging to Preem and SAF. Even though SAF could adapt the features of the technical resource of the algae to fit Preem's facility, the incentive for Preem to invest in developing a sustainable alternative to oil was not sufficient.

There are noticeable differences in the visible interfaces of the three start-ups with regard to each of the settings. Since most of the interfaces were located in the developing setting, this setting also showed the greatest variance. Some adaptations were made only to the features of the focal resource and some were mutual adaptations at both the focal resource and other resources. Most of the technical interfaces were a result of activities related to the product development process and the production of the parts, specifically resources belonging to either a developing or a producing setting. The analysis also revealed mixed interfaces (Jahre et al., 2006) visible in not only a developing context but also a using context. In this case, the organizational resources such as knowledge and routines had a huge effect on the way the focal resource were shaped to become valuable in a using setting.

Each resource interface revealed features that triggered some kind of reaction in the interface, referred to as a *trigger*. These made changes necessary, i.e. a reaction from a trigger is referred to as a *change*. In other words, they resulted in what Håkansson and Waluszewski (2002a) refer to as *friction*. Moreover, a change, in turn, can act as a trigger in another resource interface. Hence, based on the analysis of the way resources are combined in the three settings (RQ1), it is now of interest to analyse how resource interfaces are connected through interaction (RQ2).

Friction as a concept is explained as the resulting reaction when directing a force towards a specific resource which at that time interacts with other resources (Håkansson & Waluszewski, 2002a). It also results in: (i) distributing the reaction to all resources that have interfaces with the focal resource, which in turn (ii) creates tensions in the interfaces between these resources and (iii) affects the resources differently depending on the specific point in time. Taking the starting point in the variation of identified resource interfaces in the three business network settings, it is evident that the majority of the interfaces contain features, which creates friction. As mentioned by Håkansson and Waluszewski (2002a), friction is a common phenomenon when trying to change a resource connected to other resources. It is through this process that the resources are given new features and become valuable.

As seen in the case analysis, a number of reactions resulted from misalignment of features visible in the resource interfaces. One example is SAF, which had to adapt its own resources or even change collaboration partner completely. Two examples of how the changes in one resource interface were distributed to connected interfaces are presented below. Firstly, as illustrated in Figure 19, the technical interface (Dubois & Araujo, 2006) between the algae and Renova's waste water led to a change of direction for SAF. As the level of nutrition was too unstable in the waste water for the algae to grow at a constant rate, it triggered a change in the interface between the algae and the waste water, which in turn required adaptation of the features of either the algae or the waste water, i.e. either the algae had to change its intake of nutrition, which was practically impossible, or the waste water had to be modified to contain a more stable level of nutrition, which was not easy to do as the water was a product of the community's waste. In this case, it was easier to change to a completely new interface. SAF therefore stopped using fresh water and started using saltwater. This technical interface was considerable easier to manage as the level of nutrition was more stable, which ensured constant growth rate of the algae.

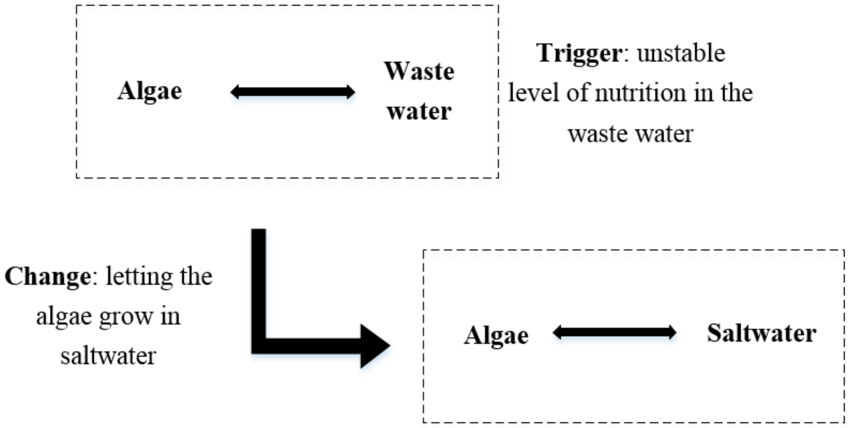


Figure 19. A trigger in the technical interface between the algae and the waste water required a completely new interface between the algae and the saltwater

Secondly, the technical interface between the algae and Preem's facility also faced some friction, as the level of nitrogen in the biomass was too high to fit into the existing facility. The high level of nitrogen in the algae acted as a trigger to change the features of the algae. This change in turn acted as a trigger in the connected technical interface between SAF and GU. The adaption of the algae thus required a change in a connected resource interface between the algae and GU's facility. In order to lower the level of nitrogen, the production process at GU had to be adapted by adding an extra step to the production process, as shown in Figure 20.

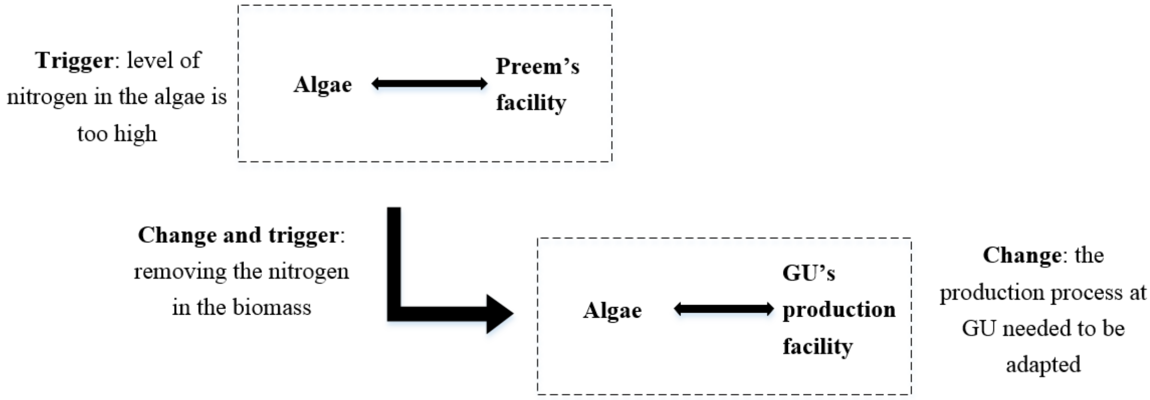


Figure 20. A trigger in the technical interface between the algae and Preem's facility required a change to the algae's features, which in turn acted as a trigger in an existing connected technical interface between the algae and GU's production facility

At this point, we need to turn from the focal resource, namely the algae, to the organizational resource interface (Dubois & Araujo, 2006) between SAF's vision and Preem's vision, i.e. as Preem saw no incentives to prolong the tests of the biomass it decided to end the R&D collaboration. The company as well as other potential customers also wanted to see a functioning demonstration plant before actually investing. As a result, SAF decided to focus on developing the silica application instead, together with a partner in France, with the aim of using the silica shell in batteries. This resulted in a new technical interface that revealed features in the silica shell, such as oxide, which were not useful in the battery. Unfortunately, neither SAF nor the partner in France was able to remove the oxide and the R&D collaboration ended, as shown in Figure 21.

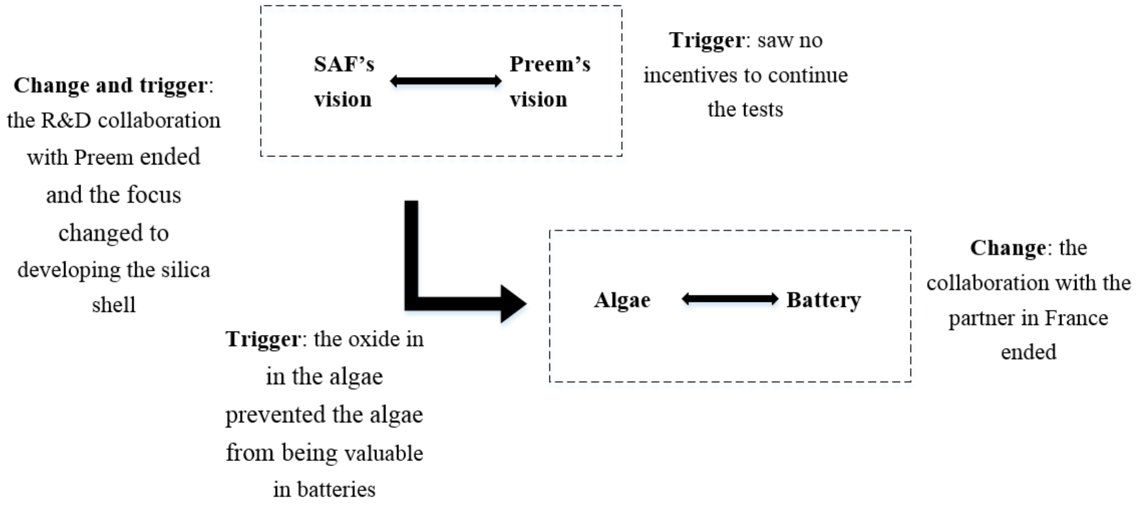


Figure 21. A trigger in the organizational interface between SAF's vision and Preem's vision created a new technical interface between the algae and the battery

The analysis of Aqua Robur's resource interfaces also reveals another type of connected interfaces: the focal resource, both in terms of the turbine and the generator, which creates a number of interfaces through its interaction with external resource collections. From the technical interface between the turbine and the water, it was evident that the features of the water had an impact on the features of the turbine. To be precise, the specific flow of the water, which was necessary to maintain for the water to reach all the houses, placed demands on the construction of the turbine to avoid big pressure drops, i.e. by extracting too much energy from the water, which in turn reduces the speed of the water flow in the pipe. The trigger in terms of the turbine's ability to extract too much energy resulted in friction. The turbine thereby had to be adapted by changing the existing coil. This change in the existing features of the turbine acted as a trigger in the connected interface between the generator (as part of the turbine) and the supplier at Kalmar's production facility, which was not able to produce the coils necessary to avoid pressure drops. It therefore had to change or, in other words, adapt its production process. The new technical features developed in the interface between the generator and the production facility in Kalmar also acted as a trigger in an additional connected technical interface. That is, the adapted generator now had new configurations and abilities to produce electricity. This in turn affected the amount of electricity that could be used when collecting measurement data in the measurement device. The amount of measurement data needed required a specific amount of electricity. The new configurations of the generator acted as a trigger in the interface between the turbine (and generator) and the measurement device, which in turn created demand to adapt the production processes at the supplier's facility in Kalmar. As a result, the technical interface between the generator and the supplier in Kalmar's production facility was exposed to triggers from two directions, as shown in Figure 22.

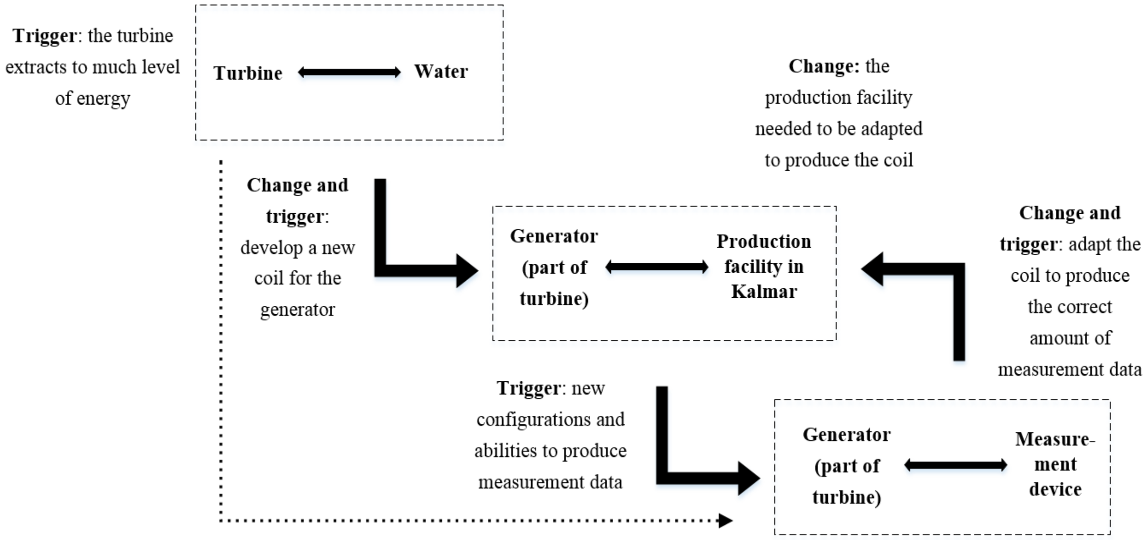


Figure 22. A trigger in the technical interface between the turbine and the water impacted the indirect, connected technical interface between the generator (as part of the turbine) and the measurement device. In turn, the intermediate interface, between the generator and the production facility in Kalmar, was impacted by both of the connected interfaces

Moreover, as can be seen in the analysis of Mevia's resource interfaces, it is clear that changes in one interface had an impact on the connected interfaces. The focal resource, including the package, IT system and GSM module, was confronted by a number of resources, which made the resource interfaces visible. Firstly, the mixed interface (Jahre et al., 2006) between the smart package and the organizational resources at the retirement home revealed difficulties in combining the existing knowledge of the users with the technical features of the smart package, i.e. it was hard to mount the package with the GSM module due to the lack of experience at the retirement home. This triggered a change in the mixed interface and forced Mevia to adapt internally, specifically the technical interface (Dubois & Araujo, 2006) between the GSM module and the package to achieve a better fit. In turn, this change acted as a trigger in the interface between the GSM module and the package, as shown in Figure 23.

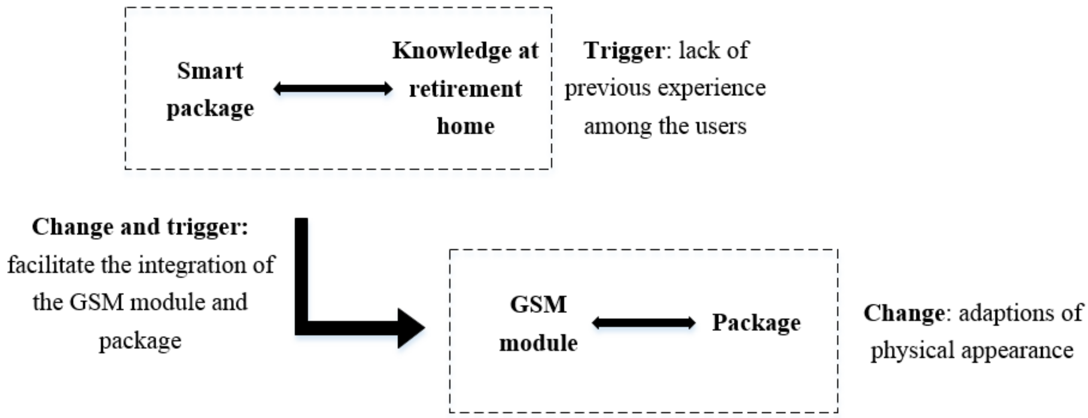


Figure 23. A trigger in the mixed interface between the smart package and the retirement home's knowledge called for a change to the internal resources of the smart package to achieve a better fit. This in turn acted as a trigger in the interface between the GSM module and the package, which required a change to the features of both of the resources involved

The above analysis reveals five different ways in which resource interfaces are connected through interaction: (1) a trigger in one technical interface leads to a completely new technical interface, (2) a trigger in one organizational interface leads to a completely new technical interface, (3) a trigger in one technical interface leads to adaptations in a connected technical interface, (4) a trigger in one technical interface impacts an indirectly connected technical interface and creates a loop back to the connected technical interface, and (5) a trigger in a mixed interface impacts an internal technical resource interface. By analysing how resource interfaces are connected through interaction, and thus answering the second research question, it is now of interest to dig deeper into the implications of these findings in chapter 7. However, before doing that, it is important to discuss how the start-ups work with proximity of the three business network settings. This will create an understanding of the complex situation of being a newly established firm with limited resources that despite the limitations needs to reduce the differences between the three settings in order to embed the focal resources within them.

6. Discussion of proximity of the business network settings

According to Håkansson and Waluszewski (2007), to create an innovation, a firm's resources have to become embedded in developing, producing and using contexts. Thus, the logic of the three business network settings are strongly related to the resource dimension. Now it is time to discuss how the start-ups work with reducing the differences between the settings in order to embed the focal resource within them. To be able to this the discussion takes its starting point in the analysis in chapter 4, however, instead of focusing on the resource dimension there is a need to see the bigger picture and thus take the starting point in the perception of the start-up as an *actor* that performs a number of different activities together with other actors in the three settings. As the previous analysis reveals, and which is also in line with earlier studies, there are times when the three business network settings overlap. One example is when companies decide to develop the product in collaboration with a potential user to acquire a better understanding of what the user requires. Another example is to involve potential and existing suppliers in the development in order to produce the innovation in the future.

There are also situations in which the settings appear far apart, which can make it difficult to embed the resource in them. As Ingemansson and Waluszewski (2009, p.22) state: "*…the larger the difference between the developing, producing and using settings, the larger the difficulties to create anything new that will fit into all these settings, and consequently, the larger the difficulty for the new to become an innovation.*" Baraldi, Gregori, and Perna (2011, p.849) develop this further by giving two indicators for favouring technological embedding: "*the more the shapes a technology can assume and the more each of these shapes involves actors acting simultaneously in different settings, the easier it will be to embed.*" As seen in this study, it is particularly important for start-ups to reduce the differences between the three settings, as the focal resource is often seen as new to the network, and it is therefore hard to understand if it will become a product that other actors are willing to use or produce. In other words, by involving potential users and suppliers as developing partners it is possible to achieve resource combinations.

One way to understand how a start-up works to reduce the differences between the three settings is through the concept of proximity (Boschma, 2005; Freel, 2003; Knoben & Oerlemans, 2006; Romijn & Albu, 2002), which was previously extended to include not only geographical proximity but also other dimensions such as social and organizational proximities between firms. Cantù (2010) also identified technological, cognitive and vision proximity as relevant elements in order to support innovation taking place in business networks. Technological proximity is referred to as shared technological experiences between two actors, whereas vision proximity is related to goal setting and the aim of the innovation. Cognitive proximity refers to how actors perceive the world and the sharing of mutual interests.

The case analysis shows the importance of working with different kinds of proximity dimensions to reduce differences between the settings (Baraldi et al., 2011; Ingemansson & Waluszewski, 2009). Looking at *the intersection between the developing and using settings*, all three start-ups worked actively with potential users of their products already in the product development process. Aqua Robur, for example, deliberately chose to work with a potential user, namely K&V. To bring the developing and using settings together to develop a product that the potential user is willing to buy, Aqua Robur chose a developing partner with technical experience of maintaining water pipes. K&V possesses experience as well as a collection of resources that, in combination with Aqua Robur's turbine, paved the way for developing the innovation, i.e. the idea that Aqua Robur had from the beginning could be implemented in a using context. This could be referred to as technical proximity, which Cantù (2010) describes as *"shared knowledge and experience"*. As Aqua Robur lacked knowledge of the specific industry and customer requirements, it had to engage and share knowledge with a partner that could reduce the distance between the developing and using contexts. Moreover, K&V possessed valuable connections to potential buyers of the product, such as the actor Kaktus. In the case of SAF, it tested the biomass application with Preem, which was initially an outcome of the shared vision of creating a sustainable alternative to oil production. The technical and vision proximity dimensions were both visible and reduced the differences between the developing and using settings, even though Preem left after a while. With regard to Mevia, it collaborated with the retirement home to understand potential users' requirements. One way to also reduce the distance between the developing and using settings was to choose a developing partner located close to the start-up. Hence, gaining geographical proximity was highly relevant, as long journeys would have resulted in higher costs. For Aqua Robur, having both K&V and Kaktus nearby made it easier to conduct regular tests at K&V's facility and to initiate discussions with the potential buyer Kaktus, which was a prerequisite for the improvement of the turbine. This could also be seen in Mevia's case with the retirement home being located in the same city as Mevia.

Looking at *the intersection between the developing and producing settings*, all three start-ups tried to engage potential suppliers already when developing the future innovation, with varying degrees of success. One example is SAF, which saw the importance of deliberately embedding its resources in developing, using and producing settings simultaneously by taking part in the initiative in Sotenäs. A parallel can be drawn to the work by McGrath and O'Toole (2013), who stress the importance of being *"born into"* networks of technology and finance to facilitate fast growth of entrepreneurial firms. By working with Rena Hav and AH Automation, SAF could develop a harvesting technique for the algae cultivation while at the same time developing new applications for the algae. As the applications of the algae changed rather fast, it was necessary to work in parallel on embedding the algae into the developing and producing settings to be able to adjust the technique. The geographical dimension has been very important here, which is also in line with Freel (2003)'s discussion on the general view that the local environment and closeness to innovation partners are more important to novel innovators than incremental ones. As seen in the case of SAF, both the technical and vision dimensions (Cantù, 2010) are important to 'bridge' the two settings of developing and producing. The vision dimension has been crucial, as the radical innovation requires suppliers that are willing to invest money and time into developing something completely new to the network.

Mevia and Aqua Robur, on the other hand, both took a more incremental or 'calmer' approach in which the less radical innovations required limited product development collaboration with suppliers. Nonetheless, the printing firm was willing to use its technical experience to adapt its process to facilitate the printing and testing of the conductivity of the packages. Furthermore, the supplier in Kalmar agreed to adapt its production process of Aqua Robur's coils to suit the new demand regarding the level of electricity produced in the turbine. At first, technical proximity on its own was not enough to engage the supplier in Kalmar in the development of the product solution. It was necessary to also create vision proximity, i.e. the supplier needed to understand and agree to share the risks in order to create this new product. It resulted in a compromise in which the supplier was willing to adapt as long Aqua Robur paid for the coils.

When looking at *the intersection between the using and producing settings* it is, at first glance, not crystal clear how the start-ups bring the two settings closer. Looking at the developing and using settings as well as the developing and producing settings, there are, for example, actors that have dual roles, such as K&V, Preem and the retirement home. However, bringing the producing and using settings closer is more about meeting the requirements of the potential users and hence facilitating the communication of these requirements for existing suppliers. In the case of Aqua Robur, K&V's requirements (when acting as a potential user) also affected how Aqua Robur's consultants (in the producing setting) should carry out their work. There is also one example of the differences between the using and producing settings being too great to work. Aqua Robur's business relationship with the supplier in Kalmar dissolved at first, as the supplier could not deliver the components that were important. These demands were a direct result of what the potential users wished to use. SAF provides another example of how the using and producing settings are brought together. By integrating the algae into a context in which both the potential users and producers were located, it was possible to reduce the differences between the two settings.

From a managerial point of view, the start-up manager needs to be aware of the importance of working with proximity of the three settings to making it possible to embed its resource into developing, producing and using contexts. This requires a holistic view of the network and the potential actors that may be affected by the activities going on in one specific business relationship. Three ways of working that reduce the differences between the three settings were identified in this study. Firstly, by working with an actor that takes a dual role, a situation that has been much researched before (see eg. Coviello & Joseph, 2012; Greer & Lei, 2012; Handfield et al., 1999), the potential requirements of the using and producing settings can be met early on in the product development process, by working with either a developing partner that can also be seen as a potential user or a supplier that is also involved in developing the features of the product. Secondly, the start-up itself can act as a facilitator between two settings (or two actors) by translating and taking specific requirements from one setting to another. This requires the start-up to work with both cognitive and vision proximity. As Huber (2012) emphasizes, cognitive proximity is a prerequisite for effective communication. Thirdly, the start-up can work with bridging ties. This may be close to what Scholten, Omta, Kemp, and Elfring (2015) refer to as bridging ties: the bridging of two disconnected networks, and specifically the importance to university spin-offs of connecting to parts of networks that have not been accessible before. In the case of Aqua Robur, the developing partner K&V could be perceived as the bridge between the two settings' networks by bridging to the potential customer Kaktus. Even though it is important to work with several actors at the same time to meet the requirements in all three settings, it is always a matter of balancing the effort of networking with the time and resources it takes to be involved in several parallel projects.

7. Concluding discussion

The aim of this thesis is to develop an understanding of how start-ups relate to different components in business networks. To fulfil the overall aim, two research questions were analysed. The first research question concerned how resources are combined in the three business network settings (RQ1), for which the following conclusions can be drawn. Firstly, for a start-up to embed its resources in the three business network settings it is of importance to adapt its resources to fit into existing resource collections. In this case the resource interfaces are identified as critical as it is in these the potential confrontation between resources occurs. Namely, it is in the interfaces one can determine whether two resources fit together in terms of how the resource features are aligned. It is also in the interfaces the answers are given whether an adaptations of features need to be made or not, as well as how they should be carried out. For example the algae had features which were not aligned with existing resource features in the network and this made it hard to embed the algae into the existing resource structures and thus make them useful to others. One example is the resource interface between the algae and battery, which revealed a need to remove the feature of oxide of the algae in order to make parts of the algae work in batteries. Another example is Mevia and the need for adapting the smart package's features such as the configuration between the package and the GSM module to enabler a better fit into the working routines at the retirement home.

Furthermore, it is often not enough for only the start-up to make adaptations, the counterpart must also see the value of using the start-up's resource and make it possible to include it in its own resource collection. The study clearly showed that the main focus was on the focal resource's adaptations of features when the aim was to embed the focal resource into an established firm's resource collection. The lack of mutual adaptations can be explained by the heavy resource structure visible at the established firms, i.e. the difficulty of changing an already established resource collection. Even though most of these business relationships ended after a while, the start-up often gained knowledge to take with it to the next relationship. However, there were resource combinations that resulted in mutual adaptations. The reason these were achieved could be the size and/or age of the partner. The study showed that these kinds of counterparts were at a stage at which they saw the benefit of facilitating the integration of the start-up's resource and were flexible in changing their resource collections. One reason could be that there were fewer connections to other firms' resource collections.

It is also interesting to note that the more new or radical the resources are, the greater the modification potential when it came to achieving versatility. One explanation may be the many application areas that the innovation could potentially be able to develop in. This becomes clearer when looking at the incremental resources, with a lower level of versatility and just one or two application areas, which often gained new value, mainly through resource combinations. It would be interesting to study the connection between the number of application areas of an innovation and the way a resource can gain versatility (either due to modification or resource combination) further.

The second conclusion for the first research question regards the importance of proximity of the three settings. As seen in the previous discussion, it was clear that the start-up worked on reducing the differences between the three business network settings in order to meet the requirements in all three settings and hence be able to embed its resource into them by working with actors that take a dual role, acting as a facilitator or using bridging ties.

The second research question concerned how the resource interfaces are connected through interaction (RQ2). The analysis revealed five different ways in which resource interfaces are connected:

(1) A trigger in one technical interface leads to a completely new technical interface
(2) A trigger in one organizational interface leads to a completely new technical interface
(3) A trigger in one technical interface leads to adaptations in a connected technical interface
(4) A trigger in one technical interface impacts an indirectly connected technical interface and creates a loop back to the connected technical interface
(5) A trigger in a mixed interface impacts an internal technical resource interface

Relating can thus be seen as a way of handling friction, and friction in turn can be understood as an interplay between triggers and changes taking place in the connected resource interfaces. This leads to the final sections of this thesis, specifically, how this new knowledge can be used in further research.

7.1 Towards a framework of specific connected resource interfaces

With the previous analysis in mind, it can be said that friction is inevitable and also necessary when start-ups try to shape their resources to fit into developing, producing and using contexts, in other words, try to commercialize their ideas. With regard to the start-up's continuous trial-and-error process of finding suitable application areas, it is important to take into consideration that changes that are made today in one specific resource interface may impact future resource interfaces, connected to both the focal resource and other resource collections located at other firms.

This can be illustrated by taking SAF and the embedding of the algae into developing, producing and using contexts in Sotenäs as an example. At the time of writing this thesis, adaptations are being made between the resources of SAF, Rena Hav and AH automation. It is therefore relevant to adapt the features to enable a future test plant by developing a suitable harvesting technique and connecting Rena Hav's fish farm to the algae cultivation. Consequently, the adaptations planned in the interface between the algae and Rena Hav's fish farm facility to enable a test plant will have an impact on Rena Hav's resource collection. The algae cultivation will be built on top of the future fish farm facility and a water pump integrated to transfer the water from the fish farm upwards to the algae cultivation. In turn, all these adaptations of the fish farm facility may not only have an impact on Rena Hav's resource collection but also on any business relationships the company has with users of the cultivated fish or actors connected the biogas plant in Sotenäs. These business relationships will probably result in Rena Hav's resource collection combining with these actors' existing resource collections. That said, the specific changes made in the interface between the algae and the fish farm facility may impact how the fish farm functions in relation to other resources over time.

To illustrate the idea of specific connected interfaces and approach a framework to analyse it, the case of SAF is replaced by a more general perspective, i.e. how a change in a focal resource interface may lead to changes in a specific connected interface in the business network in the future. As shown in Figure 24, on the next page, the changes in the focal resource interface (RI_{R1-R2}) have (over time) impacted on the directly connected interface (RI_{R1-R4}) in several different ways. Sometimes, these changes also impacted on the indirectly connected interface (RI_{R1-R5}). It can also be assumed that at a specific point in time ($t_{longitudinal}$), the specific change in the focal resource interface (RI_{R1-R2}) may have impacted not only on the resource interfaces connected to resource R_1 but also on those indirectly connected to R_1. The connected resource R_2, assumed to belong to another firm's resource collection, may be confronted by changes to its features, which in turn may affect the resource interface (RI_{R2-R3}). Both organizational and technical resources within the firm boundary may be confronted by these changes and, consequently, when reaching a new point in time, the changes in (RI_{R1-R2}) may eventually affect the resource interface (RI_{Rx-Ry}), connecting to another resource collection outside the firm boundary. When reaching this point in time, the friction in (RI_{Rx-Ry}) can be derived from specific friction in a resource interface (maybe RI_{R1-R2}) retrospectively ($t_{restrospective}$).

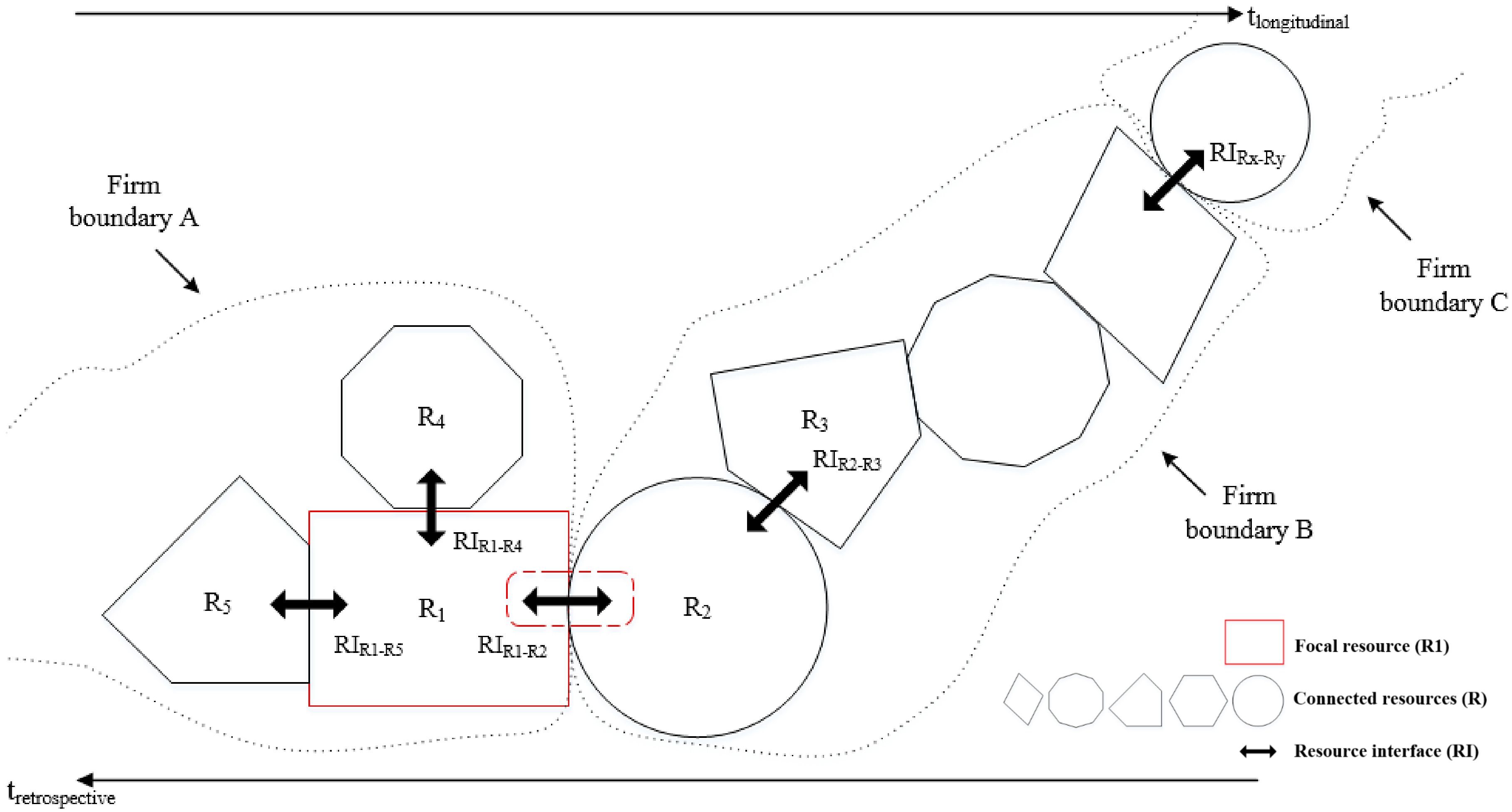


Figure 24. Analysis of specific connected resource interfaces

By continuing to study the connected resource interfaces it may be possible to bring more clarity to the way the changes spread across the business network by deriving a change in one interface over time from a change that occurred in the interface between the focal resource and the other resource at the time when this thesis is written. This may bring new knowledge about the phenomenon of relating in business networks.

7.2 Relating as a research phenomenon in business networks

The starting point of this study was the notion of the interactive view of the innovation process (see e.g. Lundvall, 2009; Rothwell, 1994) and, specifically, the innovation process related to start-ups. These firms often lack resources from the beginning, which consequently makes it difficult for them to commercialize their ideas at first (Baum et al., 2000; Coviello & Joseph, 2012). To understand how start-ups can make use of external resources it is important to not only consider the entrepreneur's personal relationships (Elfring & Hulsink, 2007; Hite & Hesterly, 2001) but also take into consideration the technical and organizational interdependencies between the start-up and other firms as they may entail both opportunities and challenges for the start-up when trying to become established (Aaboen et al., 2011; Aaboen et al., 2017).

By using the analytical tools of the Industrial Network Approach it was possible to capture the start-up's process of relating to existing components in the business network in order to develop its innovation and thus embed the resources in the network. This study shows that the start-up is in great need of adapting its resources to fit into the existing resource constellations in the developing, producing and using contexts to be able to create an innovation. Nevertheless, it is a prerequisite to also work with actors that are willing to and able to adapt their own resource collections to let the start-up's resources fit into their existing resource structures. Furthermore, the adaptations made in one interface may impact on other connected interfaces.

The aim of the thesis is regarded *relating* as a process in the context of start-ups, however, *relating* may also be seen as a general phenomenon in business networks and as strongly connected to resource development in interaction. The start-up as a study object can thus also be used as a means to understand the business network and, particularly, to see *relating* as a way of handling *friction* over time. By taking the starting point in the resource interfaces and following how the resource features are adapted over time in relation to other actors' resource features, it has been possible to capture business network processes and the concept of friction in detail. Understanding friction and how it evolves in heavy and less heavy resource structures as well as how it may impact future connected interfaces can reveal new insights into resource development in business networks and add further understanding on resource interaction as a process, as called for by Baraldi et al. (2012).

One new insight that this longitudinal study has revealed so far is the explanation of the concept of friction as continuous interplay between triggers and changes. To understand resource development as a process, there is a need to understand the underlying mechanisms of why it happens and its consequences (Bizzi & Langley, 2012). What are the mechanisms that trigger a change in one interface? How will that change imprint future resource interfaces? In this case, the resource features play an important part as they trigger a change in one resource interface, which in turn calls for a change in either the existing interface or a connected one. This in turn can trigger new changes in other connected interfaces. By using the notion of understanding friction as interplay between the trigger and change, there is a possibility of further studying the area of specific connected resource interfaces, as touched upon in Section 5.1.

When it comes to further research, and particularly the next step in this study leading to the doctoral thesis, it will be interesting to move away from the start-up as a research phenomenon and, as mentioned before, use it as a means to understanding *relating* as a phenomenon in business networks by following how one trigger in one specific resource interface will lead to changes in a connected interface a couple of years ahead. The next step will therefore be to continue studying the start-ups from this study and add additional firms as part of the project *Technology-based start-ups as engines for renewable energy* funded by the Swedish Energy Agency. That is, to develop new knowledge on how technology based start-ups establish in networks and how existing resource structures both facilitate and hinder commercialization of new innovations in terms of renewable energy solutions. As stated by Håkansson and Waluszewski (2002a) and shown in this licentiate thesis, it is in the interface between resources that the features of resources are determined and also here that the value of the resource is shaped. By taking the point of departure in the resource and using the resource as a unit of analysis it will be possible to move deeper into the complexity of resource interaction and continue building further on the work of Håkansson and Waluszewski (2002a) and Dubois and Araujo (2006).

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