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## Centre for an Energy Efficient and Competitive Industry for the Future



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| Abstract |
|---|
| This report aims to contribute to growing body of knowledge about industrial symbiosis by portraying success factors that can facilitate the formation of future industrial clusters and symbiosis. While many elements are identified in the scholarly literature as enablers, it is important to notice that such elements might be highly contextual. Drawing on the insights gathered in the Tham's cluster case study, the report describes how the specific elements are playing a positive role in the formation of the cluster. The elements presented are: existing infrastructure and early resource exchange; formal and informal networks; champions, entrepreneurial individual and boundary spanners; meeting arenas; culture (trust, local identity, attitudes and traditions); maintenance of interest and commitment; proactive local and regional administrations; external visions and discourses; and external R&D environments; visualization of identity and opportunities. The goal is to describe, not only what the elements are, but qualitatively how they work and interact in this particular context. The idea is that the reader should be able to develop a deeper understanding of the elements, applicable to other contexts. |

## Table of contents

# 1    Introduction

This report aims to contribute to growing body of knowledge about industrial symbiosis by portraying essential success factors that can facilitate the formation of future industrial clusters. The success factors presented here are based on empirical studies rather than being based on a literature review. The idea is to be able to show in empirical detail how the particular factors is at work. However, the factors identified in the present report confirm the general tendency in other studies (see Walls & Paquin 2015 for an overview).

An industrial cluster can be defined as a geographic concentration of interconnected industries, suppliers, and associated institutions with a certain degree of formalized cooperation (Chertow 2000). In this report we pay particular attention to the cluster as a means to achieve industrial symbiosis. We define industrial symbiosis as exchange of energy, materials and other resources in circular patterns where waste flows of companies are utilised as recourses for other companies (Chertow 2000). Several elements play a key role in the formation of such entities. Although some elements are identified in the scholarly literature as enablers (Walls & Paquin 2015), it is important to notice that elements might be highly contextual.

Drawing on the insights gathered in the Thamsklyngen (hereafter, Tham's cluster) case study, the report describes the specific elements playing a positive role in the ongoing formation of the cluster. It is, however, out of the scope of this report to describe the formation process in detail. This is the scope of the HIGHEFF report D4.3 _2019.04 "In depth studies of new clusters". The present report shows ten different key elements in the formation of the clusters:

- Existing infrastructure and early resource exchange
- Formal and informal networks
- Champions, entrepreneurial individual and boundary spanners
- Meeting arenas
- Culture: trust, local identity, attitudes and traditions
- Maintenance of interest and commitment
- Proactive local and regional administrations
- External visions and discourses
- External R&D environments
- Visualization of identity and opportunities

The report continues as follows: in the next section the case, Thamsklyngen, is introduced; section three describes the methods deployed in the study; section four presents the findings; and finally, the last section summarize main insights and draw some conclusion that might be relevant for other scholars and practitioners concerned with industrial symbiosis and the formation of industrial clusters .

# 2    The case: Thamsklyngen

The industrial brownfield Grønøra is located in Orkanger, a small town in the Orkdal valley, in Central Norway. The town has around 8000 inhabitants. Although farming and logging were the dominant trades in this valley for a long time, Orkanger is most known for its industry nowadays. The historical roots of such industry can be traced back to late 1800's, when the business ventures of the nationally

renowned architect and big-man Christian Thams took place. He established a number of local industries ranging from production of prefabricated houses to copper mining. Since then, the valley has become increasingly industrialized. Today, Orkanger is hosting two major Ferro-silicon plants as well as oil and gas supplier industries, which are the two main pillars of the local industry. Around these pillars, a vast undergrowth of SME's is steadily contributing with mechanical, electrician, welding, cleaning and other necessary services for the larger industries, most of the located at the brownfield Grønøra. In 2017, these local industries formalized their network in what it is called "Thamsklyngen" (Tham's cluster), named after the industry founder Christian Thams. The network aims explicitly to foster industrial symbiosis in the area and facilitate the "green shift" in Orkdal.
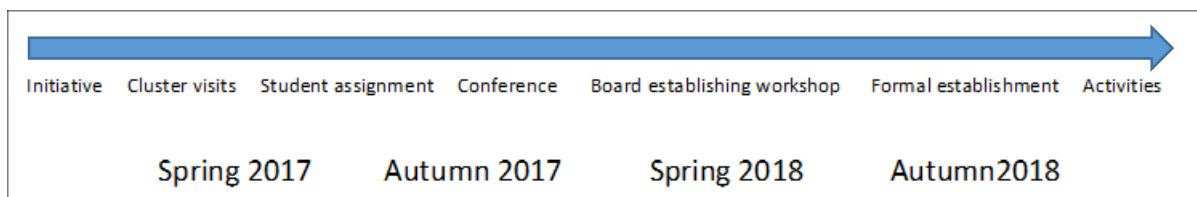


Figure 1: Brief timeline showing central events in the formation of Tham's cluster

# 3 Method

This report draws on both insights from existing literature, as well as, from data gathered by means of ethnographic methods, in particular, interviews, participatory observation and dialogues. The researchers conducted a longitudinal study to follow and document activities and processes comprised under the assemblage of an inter-organizational network. Orkdal was chosen as case study due to two main reasons. First, due to a suitable timeframe, which allowed researchers to study the early stages of network formation in real time. The industry was in the process of establishing a cluster with symbiotic ambitions during the same time of the study, which started in June 2017 and lasted until the autumn of 2019. Second, due to geographical proximity of the case study, which facilitate the data collection activities. Both reasons turned into being considerable advantages for the study. The empirical research was conducted in close connection to the hermeneutical development of research questions and theory during the research period (cf. Ulin, 2001).

## 3.1 Ethnographic data

The primary ethnographic methods to gather data in the fieldwork were interviews, participatory observation and dialogues.

### 3.1.1 Interviews

We conducted 13 semi-structured interviews, lasting approximately an hour each. Interviews were face-to-face and took place in the informants' offices in Orkdal, apart from two who had office in the nearby city of Trondheim. This allowed the researchers to learn more about the different industries' facilities through guided tours at the larger plants. All interviews were recorded and transcribed. Interview-guides were adjusted every time to capture ongoing developments in the cluster formation.

### 3.1.2 Participatory observation

The researchers participated and observed central events in the pre-cluster formation and during cluster formation processes, such as meetings (start-up, work group, etc.), workshops and social events. These events gathered potential members of the cluster and other local people with an interest

in the process. The participation of the researchers was considered carefully in relation to the observations made, following ethnographic methods for participatory observation (Ellen 1982). At certain occasions, the researchers also contributed to the event by informing the participants about the research and perspectives on the on-going process. Observations were not recorded, yet notes were taken and later transcribed. Observations were used to complete data from interviews with impressions about social dynamics in play.

### 3.1.3 Dialogues

During the research process, researchers had several meetings with the main stakeholders in the cluster, most notably the manager, where findings were presented and discussed. This worked as an important quality check and gave valuable feedback to the researchers.

In the same manner, the feedback loop made possible for relevant stakeholders to take into account research findings and other types of inputs on meeting agendas, arenas, and information exchange. As such, this study has some elements of action-research.

## 3.2 Analysis of data

The researchers analysed the data in joint analysis sessions. The main objectives in such sessions were to construct a timeline of the process, as well as, to map relevant actors, activities and events in the formation of the network.

# 4 Important elements in the formation of Tham's Cluster

In this section, important elements in the formation of Thamsklyngen will be presented and their significance and characteristics will be discussed. To begin with, key factors for the formation of this cluster can be grouped into external and internal contextual conditions. External context conditions refer to elements that are beyond the borders of the valley. On the contrary, internal conditions describe elements that were already within the local community. Table 1. Provide an overview of the different elements divided in external and internal elements.

Table 1. Overview of external and internal contextual elements for cluster formation found to be at work.

| Internal context elements | External context elements |
|---|---|
| Existing infrastructure and early resource exchange | Supportive and proactive local and regional authorities |
| Formal and informal network | External visions and discourses |
| Champions, Entrepreneurial individuals and boundary spanners | External R&D environments |
| Meeting arenas | |
| Culture: trust, local identity, attitudes and traditions | |
| Maintenance of interest and commitment | |
| Visualization of identity and opportunities | |

## 4.1    Existing infrastructure and early resource exchange

Arguably, a very important existing condition leading to the cluster formation is the previous existence of much of the infrastructure needed for a cluster with symbiotic relations. Most industries were located at Grønøra industrial park, or in its surroundings which are connected by roads, electric supply and for parts of the area, district heating. District heating was the most visible exchange before the formation of the cluster. The system uses the excess heat produced in the cilium plant at Thamshavn and has been operative for many years. At the beginning, it was utilized only to heat the local football field and in a later step, the district heating system was set up. While in an initial phase it was run by the plant, nowadays it is Orkdal energy, a local energy provider in change for providing heat for dwellings and industries at the eastern side of Grønøra industrial park.

## 4.2    Informal and formal networks

Similar to other small communities in Norway, Orkdal is characterized by its multitude of formal and informal local networks. Both types of networks have played a very important role in the different cluster formation phases.

First, regarding formal networks, the valley has been historically characterized by active collaboration between industries, both vertically and horizontally. The first type involves contact and collaboration within supply chains. The later refers to contact and collaboration across the large undergrowth of SME's supporting the larger industries. For instance, horizontal collaboration has involved shifting personnel between the industries in line with changing conjunctures in the sectors as well as workload. Yet, collaboration across industry sectors has been very scarce.

The findings point to a rich meeting culture in the valley. There are many associations and arenas where different people meet each other. Findings show that several key actors are part of a strong network in Orkdal, and in some instances, could build (on) new network relations inside and outside the valley. Indeed, in terms of pre-existing networks, the findings point to three important cases: where an Oil Forum which gathered the oil and gas suppliers, and as well as, regular breakfast meetings at the local bank, gathering industry leaders from several actors. In addition to being centred around the large industry sectors, the existing formal tie networks are described as 'top heavy' arenas where mostly managers have been present. As the cluster manager pointed out, a local gas station owner once asked him if the new cluster initiative was "just another cigar club".

Second, small regions are often characterized by existing informal networks, which also the case for Orkdal, especially among the top tiers in the region. Informal networks have been favoured by common interest in sports and local community life. While informal networks provide valuable boundary spanning between institutions, the lack of formal cross-sectorial arenas have limited the collaboration between the local industries. Informal networks played a very important role in making different potential actors interested and showing up at key meetings. The most noted by the informants was existing informal network between the leading actors with a high degree of trust between them.

The degree to which networks between important (local) organisations can be built to secure long-lasting commitment and cooperation also seems to be of significance. We understand partnerships, both, as less formal partnerships, such as local business networks, and more formal networks, such as actors with different professional backgrounds forming the board of directors of a renewable energy organisation. Community spirit and networks seem to reinforce each other leading to a commitment to social relations, which can support the region's search for new opportunities.

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The establishment of Thamsklyngen as a non-profit membership organization represented the establishment of a formal tie network across the previous unconnected actors, now connected as cluster members. This implied introduction of formal thresholds and routines for members of the clusters. The cluster quickly attracted 27 member-organizations, mostly actors who had been involved in the previous activities.

The formalization of Thamsklyngen connects persons across industry sectors spanning different organizational levels (from top managers to shop floor participants). Emergent connections and activities arise from the cluster as an arena including waste utilization initiatives (circular economy projects) but also other initiatives that have emerged from the cluster member's interactions:

> "I see a lot of opportunities here on how we can get to know each other better and use each other's knowledge in different ways, not necessarily connected to what we produce. [One company], for example, started to use tracking chips. Those you can learn to use other places. So, I am very curious on how these are used in daily operations." – Industry Representative

This legitimized new form of collaboration also between actors previously connected informally, as one informant points out:

> "Informal contact is informal contact. Obviously, there might be some ideas, some possibilities... I know [the board leader]. I can ask him if my daughter can use his garden to take a picture when she gets married. I know him all right. Previously we have not had any platform for cooperation". –Industry representative

While informal networks have helped to include and involve several important actors in the formation phase of the cluster, at the same time as have been an excluding device for others. In particular, the gender issue is worth of further attention. In this regard, the resulting formalized network has a very inclusive component in which actors traditionally excluded from less formal networks are now officially equal part of the project. The exclusion of certain actors becomes too visible when the network is formalized as a cluster to be possible. However, also the formalized cluster has potential for exclusion, for example of small businesses which can have problems affording the annual membership fee of 20 000NOK.

While the technical potential for symbiotic exchanges was present also before the network formation, we find that the formal network contributes to discovering or inventing, and eventually establishing new symbiotic exchanges. One way in which this happens is by establishing arenas where possible exchanges can be discovered as discussed earlier.

## 4.3    Ildsjeler: Champions, entrepreneur individuals and boundary spanners

The Norwegian term 'ildsjel', usually translated in English as champion, describes passionate and entrepreneurial individuals playing a crucial role for the success of an endeavour such as the formation of an industrial cluster. Scholarly literature notes that a determinant for the success of the project is to what extent these individual ideas are taken up by other actors in the community, and thus, to what extent entrepreneurial individuals are able to build on their significance and influence inside and

outside the community, mobilising other important actors for their cause (Klerkx and Aart 2013; Howell et al 2005).

The term 'ildsjel' can also be translated to 'boundary spanner', another term similar to champion, fulfilling the role as active protagonist for cluster formation. The term boundary spanner highlights this actor's ability to operate across boundaries, for example between industries, branches, organisations etc. and thus facilitate the dialogue necessary to take the steps towards cluster formation.

The findings show that champions and boundary spanners have played a very important role in several cluster formation phases. The entrance of local champions, into the action space brought in new capabilities necessary for the network formation. Most noted was the champion's role as node in the existing informal network between the leading actors, providing trust between them and mobilize towards the project:

> "Yes, it is easier to engage the others when someone takes the lead and says that we want this. I also already have good relationships with people here, so it was easier to motivate them to join » - Board Leader

The significance and characteristics of champions for the cluster formation suggests that they were part of strong local networks. After the initial conference, a local industry investor and representatives of the larger companies started working specifically towards forming a local inter-organizational network. While the County Council and the Business Garden had been centred at the structural holes and brokered the flow of information and network connections, following the conference other local actors-initiated network entrepreneurial activities. Most, notably a local investor with long record of accomplishment in commercial industries took the leading role in forming a steering group to orchestrate the process. As one of the informants argues, the external orchestrating entities where not in a position to form the network:

> «Even though the County Council had the idea that something could be done here, and it has been a positive contribution from them, they cannot do it. Other than supporting the establishment. » - Board Leader

Trust brokerage and taking lead in actions was important ingredients to ensure mobilization of industries to enter the action space.

## 4.4    Meeting arenas

In the above sections, the role of networks and champions have been discussed. It is however important to note that such elements usually require a physical place and/or event where to meet. Before the cluster formation, there was some existing meeting grounds for those associated with industry and business in Orkdal. As mentioned above, some of these where restricted wo to certain sectors. More general meeting grounds where:

•        The **breakfast meetings**, arranged by the local bank. These meeting were open to all and would take up relevant topics for the local industry. They appealed more to the manager segment than the worker segment.

• **_"Næringsforeningen"_** (the business association) is an association between local business stakeholders, mostly leaders. They arranged meetings and discussed topics relevant for local business, such as policy for establishment of new infrastructures.

• These meeting grounds were potentially boundary spanning, as they included actors from several sectors. Also, the local business garden (supporting the small businesses in the region) and the municipality administration played boundary spanning roles.

A key meeting ground for the formation of the cluster was the **_industry conference_** organized by the County Council, the Business Garden and other local stakeholders. The conference took place in the summer of 2017 and had a focus on the green shift and circular economy, inviting a broad range of industries in the region. The detailed findings from a student assignment on energy- and material streams in Orkdal were presented in the conference as a visual representation illustrating the lack of local utilization and refinement of industrial by-products. This presentation was key for many other local actors to become very positive about the cluster.

Another essential meeting place was the **_"idea generating workshop"_** arranged just before the formal establishment for Thamsklyngen, with a broad mobilization of industries including participants from different organizational levels in the companies, which is essential for resource exchange collaboration. These interaction arenas enabled serendipitous connections between participants. This workshop was arranged at a local meeting hall/pub/restaurant which is located in the old steam house of the old factory for prefabricated houses. The room is renovated to be a meeting/drinking/eating hall, but you still sense the old industrial nature of the room and are reminded the long industrial history of the valley.

> "We had prepared tasks where they would map their competencies, resources and so on, and then they would sit together in groups. From that, I got a lot of raw data concerning what they wanted. A good thing was that this was managers, middle managers and operators from the production side. Therefore, we got many ideas from top to bottom of the organizations. There was a lot of open information exchange that afternoon which laid the foundation for the cluster onward. Until then it wasn't really a cluster, only a project." - Cluster manager

The **_"Tham's Pils"_** – having a beer together – was also arranged several times in the old steam house. This was an informal meeting where the participants simply went out to have a good time together. Also, this seems to have been important for the cluster formation, both in the building of trust, identity and getting to know each other better, but also as an arena where ideas for collaborations was discussed.

The presence of meeting grounds was essential for the cluster formation. We have learned that we cannot simply assume that people will talk together, unless they actually are gathered at a certain meeting ground in order to talk together. This meeting bound should be considered when enhancing cluster formation.

> "[…] it is not that easy to get new contacts either. You cannot just invite yourself to a company you do not know. It is something that has to be done step by step, the cluster definitely makes it easier. Like when we had that workshop where we were forced out of our regular networks and placed within groups. Then you just have to learn to talk to the people you are sitting with,

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we get ideas and get to know each other. When you have met a person face to face, it is easier to make a phone call and refer to the meeting with Thamsklyngen and engage in a dialogue." – Industry Representative

Further, the nature of this meeting ground plays a role. The use of a room which enhances the local identity the cluster wants to be associated with seems to strengthen the effect of such meetings. Also, it is important who will come to these meetings; it seems essential that several levels of the organizations meeting are present.

Also, the meetings can benefit from being facilitated towards certain outcomes. For example, the idea generating workshop played an essential role in filling the cluster with content. A key question for the participants was what the cluster should do. In this phase, representatives from other companies brought new ideas to the table in order to align the network purpose with their own interests. Indeed, translating and making the concept of circular economy their own was a very important step in the formation of the cluster. As the following quote points to, the meaning of the concepts of "circular economy" and "clusters" were translated to fit their practical and commercial needs:

"When I heard the board leader and the Business Garden had started to look at circular economy, I thought that circular economy is not just energy or surplus heat, but can also be surplus resources, equipment and personnel between the companies. So, I am very interested in this and I know we can all profit from it" – Industry Representative

## 4.5 Culture: trust, local traditions and attitudes

There seems to be a strong local identity between actors in the "valley" as they often called their region. At public meetings we often heard people use "we", when talking about the people and the industry actors in the valley. As such, it seemed to be a feeling of "sitting in the same boat". We assume this identity to be an essential precondition for the cluster establishment.

The findings point to a high level of trust between the actors in Orkdal. Many of the locals knew each other from other contexts in the community, such as school or sport clubs. As such they operated "at the same wavelength", so to speak, and could easily understand each other's perspectives.

The long historical roots of the industry in Orkdal have contributed to a local industry culture. The value system is partly revealed through explicit statements from our informants. The culture of collaboration in the valley through vertical value chains are certainly important for the establishment of a sector spanning inter-organizational network. The informants explicitly describe aspects of this culture as an acceptance in the valley to "get dirt on your hands", "work shift" and "not lose our heads in conjunctures". It was often portrayed as if the leaders and the workers where in the same boat, which they to a certain extent are, but we should not forget that any glorification of the ability to "get dirt on their hands", "work shift" or even as we heard, "sustain pollution" has some clear negative consequences for workers; workers and leaders are not always in the same boat.

The industry representatives also express a strong focus on commercialization, a natural orientation for the industry culture, contrasting it with activities and projects triggered by public funding. As exemplified by the board leader:

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"But many such initiatives, I feel spend a great deal of time on raising public funding to fund activity for a period of time. However, what exactly is the result? Being able to show results, that is what I feel is important, and the result is not just an activity, something should actually come out of it."

The ability to grasp changes, act when boat arrived at the docs, sustain hard work and find business opportunities, are all aspects of what was often referred to as 'the Thams-spirit', inspired by the achievements of the great industrial pioneer Christian Thams who showed the valley that nothing is impossible.

The particular focus on commercialization (as opposed to R&D projects) and sceptical attitude towards public incentive programs, is an important aspect of the organizational field the public orchestrators entered. We also note that this culture sometimes stands in opposition to the intentions of the public orchestrators. I paradox that should be considered in any cluster formation initiative.

Finally, another cultural aspect is a certain boldness regarding entrepreneurship; there seem to be a low threshold for starting new businesses and introducing transformations. There seem to be a strong culture for "doers" in Orkdal, making the way short from ideas about "the green shift" and "circular economies" to action. This has been a necessary condition for the cluster establishment in Orkdal, but also something that tends to take the process out of the hands of the public orchestrators. As a result, the meaning of essential terms such as "green shift" and "circular economy" have deviated from the original meaning held by the public orchestrators.

## 4.6    Maintenance of interest and commitment

While to foster and increase interest and commitment in early phases was very important, it was as equally important to maintain these over the time and among different types of actors. The findings point to the importance of not only of raising attention and increasing interest, but the work devoted to maintaining commitment among different actors.

The most important way to achieve this was to employ a project manager to take care of the daily activities, such as connecting people in the network, talking with them discussing opportunities, organising meetings and event and provider meeting grounds. After the formalisation of the cluster, the project manager took the role as cluster manager. There was agreement in the cluster that they would not have succeeded without the manager.

"I benefit a lot from the momentum in the valley. We have had two successful large meetings where people spoke warmly of the cluster. In addition, I have travelled around and talked to many people to spread the message. We have started in a very good way". – Cluster manager

The cluster manager highlights the importance of directed information exchange in order to "keep up the momentum" and establish inside internal legitimacy for cluster activities. Further, a mission statement to "strengthen the competitive advantage of regional companies by being a driving force in the digital and green shift with a focus on circular economy projects".

In addition to the cluster manager also a steering group played an essential role in the cluster formation. This group was constituted as a cluster board in the formalisation of the network. This implied that orchestration activities such as initiating working groups, projects and information exchange were dedicated to specific roles.

Another aspect in keeping up momentum are meetings. While not exhausting the members with innumerable meetings, the meetings need to be often enough to keep momentum up. Also there seems to important that each meeting bring the project further. It should not be like meetings in a social club, but meetings that bring the process towards cluster formation one step further each time. If the members get a sense that the meetings don't lead to anything, the momentum may be lost. This requires that the project manager do some work between the meetings and that they are well planned.

Also, the members of the cluster tended to call for concrete results from the cluster project. This meant the initiation of specific collaborative project. Also, the cluster manager pointed out that in or der to keep the momentum up, they would need to show results within the first year of the formalisation. Not all members stressed the importance of showing results early, arguing that the most important thing in the start was to get to know each other better and develop trust. However, from the researcher's perspectives, it seems necessary for the cluster to actually produce results in terms of concrete collaboration projects in order to keep up the momentum and the interest among the members. The commercial orientation among most members seems to make them a little more 'impatient' than for example public orchestrators.

## 4.7    Supportive and proactive local and regional authorities

Supportive government is one factor we found to be absolutely necessary for the cluster formation in Orkdal. The involved governmental actors were the local municipality and the regional county council. In addition, the local "business garden" played an active role as intermediary between county council and the local industry.

The local municipality government played a curial role in aligning the bureaucratic processes, not tom make obstacles for the cluster formation. The municipality in Orkdal had a long history of collaborating with the local industry in order to accommodate their business as good as possible. This meant speedy bureaucratic procedures, an active and welcoming attitude toward new industries that considered settling in the valley, and a willingness to see the situation from the perspective of the industry (their commercial interests) when regulating the area, handling cases and in other ways acting as local government. When the question of cluster formation came up, the municipality was very suppurative. This was not so much due to the county council, but rather because the local industry itself was interested in this. We found close bonds between the municipality leaders and local industry leader, often taking part in the same informal networks.

The county council played a different role, but even more crucial: In late 2016, the County Council joined a Nordic project on bio-circular economy. Searching for an example case for the project, the County Council soon looked to Orkdal due to the diversity of industry and the potential of utilizing existing waste material and energy streams for industrial development. This is how the idea of circular economy and the green shift came to Orkdal.

Initially, the objective of the County Council was to find ways to mobilize key stakeholders around the concept of circular economy and trigger small-scale circular economy projects in Orkdal. From the start, the County Council reached out and took contact with Orkdal Business Garden.

The Business Garden had extensive knowledge and connections with local companies, organizations and municipality. The manager of the Business Garden early became committed to the project and essentially joined the role as a local orchestrator for the initiatives from the county council such as arranging meetings and study trips to other industry clusters to see successful examples of industrial symbiosis and circular economy:

"All the way, the County Council has been a huge supporter, financially and by arranging study trips to sites such as Kalundborg and Finland in order to mature us and the companies to appropriate the populist concepts and say that we can actually do something even better. Thus, each company can make efforts to make a smaller carbon footprint." – Business Garden Representative

The county council played an essential role as orchestrator of the early mobilising activities, but this role toned down as the local industry gradually took the role as orchestrator, allowing the county council to step back.

## 4.8    External visions and discourses

Visions and discourses around the green sift in contemporary national and global institutional contexts also reached Orkdal. For instance, the Norwegian Prime Minister launched the green shift, as a political metaphor, after the state elections in 2013. While the concept is still being criticized for being blurry, or even empty of content, it provides direction in public documents and policies. This discourse played an important role in the cluster formation process. The industry leaders acknowledge that they simply had to embrace the green shift in order to stay competitive as they saw "greenness" as one of the qualities that was going to be attractive in the future.

Circular economy and clusters emerged as a way to realise the green shift. Even though circular economy is a concept no less blurry than "the green shift", there has been a substantial encouragement from the Norwegian government towards forming clusters, aligning funding mechanisms towards such establishments. This has contributed to a growing number of industry clusters in Norway around specific industries (i.e. maritime, process industry clusters), locations (industry parks, regional clusters) and topics (i.e. energy efficiency centres). In recent years, substantial public funding also has been directed towards circular economy and energy efficiency projects. In this regard clusters are a trend (Røvik, 2016).

A few examples of circular economy (or industrial symbiosis exchanges) already existed in Orkdal before the county councils introduction of the concept in 2016; surplus heat from the Ferro-silicon plant where utilized in the regional district heating network and excess dust from the silicon production, previously a main pollutant in the region, was now used to produce micro-silica. However, these exchanges were started because they, according to our informants "were economically smart" and not framed as sustainable or green. On the whole, there was little focus on the green shift, and the concepts of circular economy and industrial symbiosis were largely unfamiliar. Thus, the efforts from the county council to introduce these concepts were crucial.

The focus on bio-circular economy and network establishment must also be viewed in connection with coinciding events and new industry establishments in the region. In 2017 it was confirmed that an industrial poultry plant had chosen Orkdal as location for its new factory, and along with them came an another food processing plant for fishmeal production, with a business model of utilizing bio-waste from chicken production as the main input factor. These exogenous drivers and events are important to understand the network formation and translations of network purpose in Orkdal.

## 4.9    External R&D environments

Research institutions tens to play a role in the formation of industrial clusters (Walls & Paquin 2015). This is also the case in Orkdal.

The most obvious role of researchers has been to assist with knowledge, calculation and technical expertise to unravel new opportunities and/or solve challenges regarding circular energy and material

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flows. Without such expertise, waste utilisation form process industry is very difficult to achieve, in Orkdal or other places.

A more surprising role of R&D is as creator of visions. The summer 2017, the County Council and the Business Garden were able to engage two students from NTNU, the nearby university, to map potentially available material and energy waste streams. The students interviewed most of the industries and made three main findings: (1) most surplus energy- and material streams are were not utilized locally, but disposed or shipped to other places for refining;, (2) there are was almost no collaboration between the companies in the region across industrial sectors;, and (3) the Orkdal industry reputation of the industry in Orkdal was a mixture of invisible and poor, due to earlier pollution issues from the larger plants. Thus, in addition to the intention of the orchestrators of developing a basic inventory of material- and energy waste flows, the students identified 'structural holes' (Burt, 2005) between the industry sectors in Orkdal. This work was particularly important for the local industry actors to see themselves in relation to the green visions and create a consciousness about possibilities. From an organizational perspective, the participation of researchers in different settings during the formation process has added an extra component of reflexivity into the process.

## 4.10   Visualization of identity and potential

Recognition of the circular elements is a necessary aspect of industrial symbiosis (Shertow 2012). The symbiosis needs to be self-conscious so to speak in order to be an entity. This is also a question of identity; for the cluster, identify as a cluster with biauricular flows. Such identity is helped by external factors, such as R&D helping the cluster participants to see themselves from outside, as an entity. One particular R&D outcome proved to be essential for the cluster formation at Orkanger. This was the waste-flow model from the mentioned student assignment on energy- and material streams in Orkdal (see Figure 2). This model was first presented for the participants in the cluster at the industry conference arranged in order to mobilise for the cluster formation. It is a visual representation illustrating the lack of local utilization and refinement of industrial by-products. It also indicates that there are lots of potential in closing these waste streams.

The visual representation was a revelation for the industries. Showing how resources were being literary (and metaphorically) thrown at the sea made a strong argument for the need for a cluster.
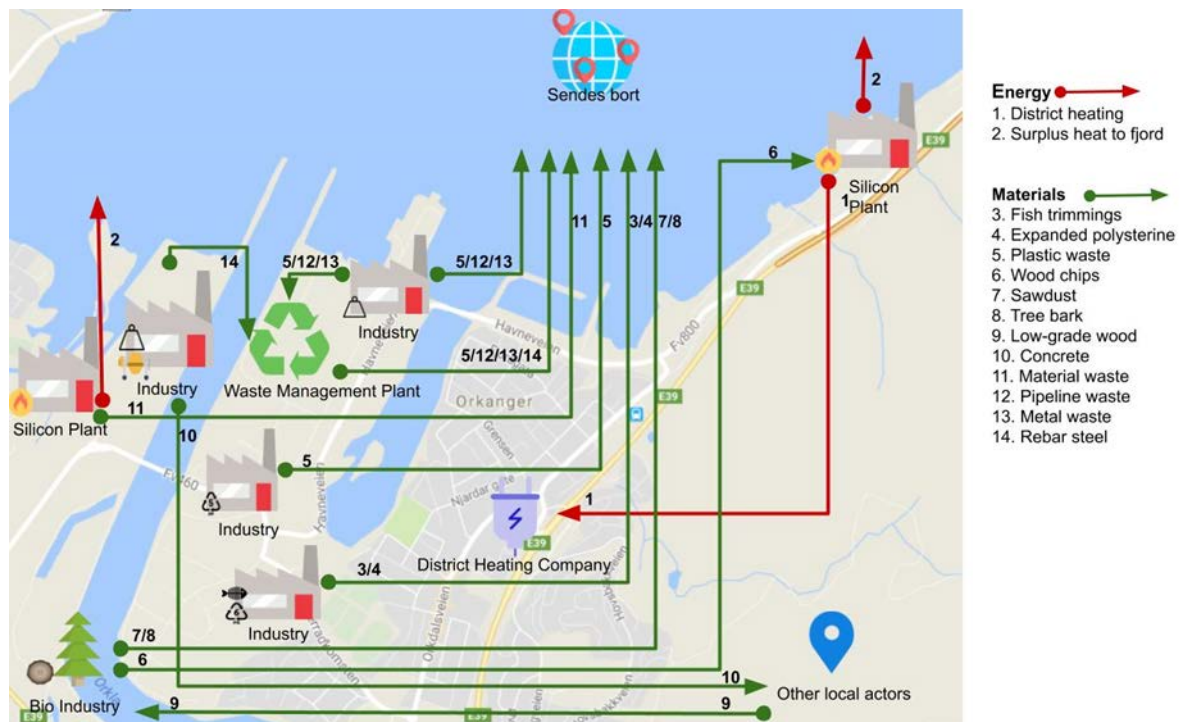
Figure 2: Representation of waste material- and energy streams in Orkdal

This image is not a purely scientific model, it also designed deliberately as an image to inspire:

> "We eventually agreed that they had to re-make the graphic so that the arrows pointed out at the sea, because that's the main point; we lose a lot here. You can see the effect of that as the model has been used for a long time" – County Council Representative

This way of revealing value through inventorying outputs (Zaoual and Lecocq, 2018). The visual representation made a strong impact at the conference and worked as a "boundary object" (Star, 1989). A boundary object is an object used to formulate and communicate ideas and visions across boundaries between people and organisations. It can be anything from a visual model to a communication channel to a concept. The waste flow model helped concretizing and aligning the local industrial interests with the concepts of green shift and circular economy.

We should note that the model worked as a boundary object across quite different ideas about what circular economy could and should be. While some actors emphasised the environmental benefits, other emphasised the economic potential in not wasting energy and materials:

> "We believe there is nothing contradictory between having a positive economic effect and an environmental effect so we will focus on both. My personal motivation has been to produce profitable growth in Orkanger and the whole region." – Industry Representative

The survivability of the model indicates the strength of this representation as a boundary object, building legitimacy for the green shift and the circular economy. It has been widely used at internal and external workshops and meetings, both before and after the cluster was officially established.

The model has proved to be an essential symbol for the Tham's Cluster bot for inspiration to collaborate and to build identity.

# 5     Conclusion

In the above sections, we have described essential elements at work in the formation of one particular industrial cluster. We have also pointed to how these elements work together. The results clearly show that the success of the cluster formation process depends not only of these elements but on the combination of all of them.

The report has focused on the cluster formation, not the establishment of symbiotic exchanges as such. The cluster is assumed to be a platform enhancing further formations of symbiotic exchanges, in particular by providing meeting grounds, spreading and catalysing ideas, and building trust. Experiences so far indicate that establishing symbiotic exchanges of materials and energy (beyond the present district heating system) meet numerous challenges in the complex relations between economic interests, need for predictability, regulations, various interest from different actors (public as well as private), and uncertainty regarding new technological solutions. In this challenging process, the formal cluster seem to play an essential role in helping the actors to sustain the challenges and find collective solutions. Establishing symbiotic exchanges is expected to take time.

This study focuses on one particular cluster. The relevance for other cluster formation processes is not as a fixed recipe to follow, but rather by providing examples to look to, both in terms of specific element, the various potential in each element, and the way the elements interact. Every cluster formation process is different. In order for the present experiences to be relevant, the reader should consider how they can be interpreted into the context he or she is studying to be relevant.

The elements presented also play different roles at different phases in the cluster formation process. By dividing the formation process in stages according to Chertow and Ehrenfield (2012), we locate the various element at the "sprouting phase", where symbiotic relations first occur; the "uncovering phase", where the cluster becomes self-aware so to speak; and the "consolidation phase", where the formation is formalised. Table 3 also separate internal from external elements.

Table 3: Success factors by formation phase

| Success factors | Formation Phase | | |
|---|---|---|---|
| | Sprouting phase | Uncovering phase | Embeddedness and consolidation |
| **Internal context elements** | | | |
| Existing infrastructure and early resource exchange | x | x | |
| Formal and informal networks | x | x | x |
| Champions, Entrepreneurial individuals and boundary spanners | x | x | |
| Meeting arenas | x | x | x |
| Culture: trust, local identity, attitudes and traditions | x | x | x |
| Maintenance of interest and commitment | | x | x |

| | | | |
|---|---|---|---|
| Visualization of identity and opportunities | | x | |
| **External context elements** | | | |
| Supportive and proactive local and regional authorities | | x | |
| External visions and discourses | x | x | |
| External R&D environments | | x | x |

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