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Resource wisdom in manufacturing SMEs

Interview study on the state of resource wisdom in the industrial manufacturing companies in Ostrobothnia

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Supporting SMEs in resource wisdom

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Resource wise society has been raised as a key theme to develop good living environment in the strategy for Ostrobotnia region. Resource wisdom aims to use environmental assets in a wise way without unnecessary waste. Manufacturing industry plays an important role in this bigger picture, which pushed Vaasa University of Applied Sciences, Design Centre MUOVA and University of Vaasa to tackle the issue in the Rewise project.

The Rewise project aims at increasing knowledge and solutions of resource wisdom in the industry. The project collaborates with the key companies in the region, Wärtsilä, Vaasan Sähköverkko and KWH Mirka as well as manufacturing SMEs. Together they create future visions of resource-wise value chains and ecosystems in manufacturing industry. Based on the visions, the researchers and experts develop demonstrations for illustrating the development activities and the environmental impact of these activities. The demonstrations support companies to plan their own resource wise strategies and development plans. The project team develops a VR-based demonstration platform for future company collaboration and research on the highly important topic. The virtual demonstrations will be presented in the events targeted at regional SMEs.

New knowledge and demonstrations will not save the world. The concrete changes do. Therefore, it is important to find out what is the hindering SMEs in taking resource wise steps, and what are the development tasks and practices in manufacturing SMEs. This collection of articles presents thoughts and practices of regional SMEs reflected with the current research knowledge.

Hopefully, you will find it both inspiring and helpful!

In Vaasa 20th December 2021

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1. Resource wisdom in Rewise project

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Resource wisdom is a relatively new concept in the field of sustainability and circular economy. Its first application areas and development projects have focused mainly on cities, and step by step, the application area has been broadening to different industries, ecosystems, value chains, and local networks.

Resource wisdom focuses on the wise use of natural resources, materials, and energy following sustainable development and circular economy principles. It can be described as "the capability to use different resources (natural resources, raw materials, energy, products and services, spaces and time) in a manner that takes into consideration the consequences" (Sitra), and it addresses wellbeing, low carbon performance, and sustainable development. The implementation of resource wisdom reflects in four key areas:

1) energy efficiency and the use of less energy-intensive solutions and renewable energy,
2) material efficiency and the wise use of natural resources[1],
3) the circular economy, and
4) the waste minimization.

Resource wisdom calls for a system-level approach, where different actors within ecosystems and value chains make decisions and implement activities to promote the wise use of resources. Some of those decisions and actions require collaborative activities, whereas some take place within the firm boundaries. However, the comprehensiveness of the solutions is critical, where maximal environmental impact is created at the system level, and instead of sub-optimization, attention is paid to the environmental impact of the solution throughout the value chain and life cycle.

It is not simple to plan and implement resource-wise solutions. For companies, this means solutions cutting across the entire production chain. They often require changes in the way businesses operate and in company processes at different value chain stages. These changes could be linked, for example, to product design, sourcing of raw materials, material and energy efficiency,

[1] The difference compared to traditional efficiency concept is that addition to purely economic and efficiency factors, it addresses also the environmental aspects and impacts related to resource consumption during the whole life cycle from material extraction to end of life.

reducing emissions through renewable energy, minimizing waste through recycling and making good use of side streams, and post-use recovery of a product's materials.

Moreover, there is no one-size-fits-all model for resource-wise solutions. Sector-specific opportunities to develop and implement energy-wise solutions can therefore differ significantly. For example, in demanding industrial manufacturing, such as in the energy sector, the regulations and quality requirements for the raw materials and materials used are pretty strict, turning the use of recycled material in manufacturing almost impossible. Instead, the waste material, other by-products, and end-of-life products of the product can be pretty valuable materials for other companies, which in the form of industrial symbiosis can significantly improve material efficiency and reduce the carbon footprint and waste. Resource-wise solutions can also be based on innovative ways to reduce energy consumption and carbon footprint, both in the company's internal processes and the various stages of product-service processes that interact with subcontractors and customers.

Measuring and verifying environmental impacts may also be challenging. Therefore, it is essential to outline the whole value chain and identify the stages and processes with the highest pressure on the environment and where changes could significantly reduce negative environmental impacts. The life cycle assessment method, which enables the assessment and verification of environmental impacts between different options, is gaining ground as a helpful method for impact measurement. However, its application requires specific skills and precise data, and it is not commonly used in industries yet.

Especially in SMEs with scarce resources, these factors can become real barriers to the development of resource-wise solutions. For this reason, the Rewise project aims to provide SMEs with the tools to understand and experiment with different ways to develop product-service processes according to the principles of resource wisdom and to assess their environmental impact holistically based on life-cycle thinking.

Thus, the development of resource wisdom approach in Rewise projects is based on the following choices and principles:

- It develops an understanding of resource wisdom, its fundamental principles, and solutions within specific industries, namely metal and forestry industries
- It approaches resource wisdom from a system perspective, focusing more intensely on those phases of the value chain and production process where manufacturing SMEs can influence and implement changes. Thus, development work and company collaboration are firmly based on the value chain and life cycle approaches

- Life Cycle Approach (LCA) is adopted as a key method for environmental impact measurement and verification.
- The concept of resource wisdom is operationalized in a company-friendly manner in a way that it uses the language and concepts that are familiar to SMEs.

Figure 1 Main stages in life cycle approach

2. Research process in Rewise SME interviews

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Karita Luokkanen-Rabetino and Rodrigo Rabetino | University of Vaasa, Vebic

In the first phase of the Rewise project, interviews were carried out to identify SMEs current practices and goals for the efficient and rational use of resources, as well as the challenges and development needs associated with them. This section describes the methodology used to select the companies participating in Rewise study. The Orbis database was the primary sampling tool to identify the relevant sectors and the companies to be interviewed. The selection process is described in Figure 2.

Figure 2 Company selection process used in Rewise study

In the first step, the search focused on active companies in Ostrobothnia, identifying 47,494 active companies of all sizes and sectors of the industrial classification. The next step was to select potential clusters. The analysis of the information identified 3,296 companies in three clusters in terms of their relative weight in the economic structure of the region: 1) food and beverages (212 companies), 2) manufacture of basic metals, metal products, machinery, and equipment (610 companies), and 3) construction of buildings, civil engineering, and specialized construction activities (2,473). For consistency and considering the project's objectives, we focused the sample even more, excluding food and beverage companies (cluster 1). Thus, the focused sample (step four in Figure 2) consists of 3,083 companies in clusters 2 and 3.

In the last step of Figure 2, the process for selecting the final sample is as follows. First, all the companies were classified by size, following the European Union classification. For 614 companies, there was no information, and they were discarded. Of the remaining 2469 companies, only nine were classified as large enterprises, resulting in a pre-sample of 2,460 SMEs. We then selected

companies with more than ten employees, believing that the objectives of our project require a specific minimum size to be able to implement meaningful actions with a particular impact. This criterion reduces the pre-sample to 597 companies. Next, a new filter was applied by reading the trade descriptions provided by the companies in the original language and searching for additional information on the websites when necessary. This last scanning resulted in selecting a final number of 192 target companies, which were ranked according to relevance to the project and ease of access when a team member had prior knowledge and contacts with a particular company. The companies were contacted by phone and e-mail. After the round of contacts, 11 companies agreed to participate in the study.

The Design Centre Muova (Vaasa University of Applied Sciences) and the Vebic research platform (University of Vaasa) were jointly responsible for conducting the company interviews. Interview framework was prepared to guide the discussion with the companies. The framework was tested beforehand with one company.

Rewise team interviewed 11 company executives in Teams/Zoom during the autumn 2020. The interviews lasted 1-1,5 hours and they were recorded and transcribed for the analysis. The interviews are confidential and the reports written on the basis of the interviews will not reveal individual companies or respondents.

3. Resource wisdom defined by companies

Veera Hautala | Vaasa University of Applied Sciences, Design Centre MUOVA

The Rewise interviews revealed that resource wisdom is a new concept for SMEs in Ostrobothnia. Many companies associated resource wisdom with familiar themes such as recycling, reducing the carbon footprint, efficient material use and the energy efficiency. Resource wisdom was also assosiated with human resources; hiring the right people and placing them in right positions in the company.

Some companies defined resource wisdom as a shared mindset. Every employee should be committed to company's goals and know how they can contribute. In terms of energy efficiency, every employee needs to understand how his or her own actions affect energy efficiency of the company, for example. The companies also felt that resource wisdom was strongly related to development activities. Resource wisdom as an approach should cover every development project. It could reveal new areas for development as well as activities that could be done more resource efficiently.

Environmental certification and practices such as minimizing waste were mentioned as an examples of practical development activities of resource wisdom. Some requirements are considered to be a burden, especially for small businesses, which have a limited capacity to invest in meeting all environmental requirements.

Many interviewed companies linked resource wisdom to material handling and recycling. In general, companies preferred choosing recyclable materials. Aluminium, for example, was seen as a good material because it can be re-melted several times without compromising the quality of the material. Some companies also prefered materials that are produced responsibly and their origin is known. This was especially important for companies that sell their products to large international companies. The utilization of waste material and the optimized production process were also considered important areas of resource wisdom.

When describing the resource wisdom, many SMEs concentrated on the activities carried out in close collaboration with their customers. Companies use their know-how to avoid unnecessary worksteps and transportation in the manufacturing process. The most important thing is a good design and proper planning of the projects. Holistic thinking can save money and environment.

Many of the interviewed companies felt that resource-wise activities play an important role in improving their financial performance. Lack of up-to-date knowledge and expertise are major factors influencing lack of resource-wise development activities. Therefore, a project like Rewise is

seen as an important and good channel for finding right networks where people are actively looking for solutions to problems.

Figure 3 Key elements of resource wisdom described by interviewed SMEs

4. Challenges in resource wisdom

Sanna Peltonen | Vaasa University of Applied Sciences, Design Centre MUOVA

This article presents the previous studies on barriers to resource wisdom as well as results of the interviews with SMEs in Ostrobothnia. Since the concept 'resource wisdom' is not widely used, we gathered studies, research papers and reports by using related concepts as 'challenges in resource efficiency/circular economy/resource wisdom/energy efficiency/sustainability in SMEs'. Since, these concepts have similar aim in promoting ecological consideration in companies, they are relevant in understanding challenges also in the field of resource wisdom.

The Rewise interviews identified various barriers to the implementation of resource wisdom in manufacturing SMEs. Many of these barriers are already discussed in the previous literature. The analysis of the research papers and reports, as well as including interviews with Ostrobothian SMEs, created a background for identifying four categories of factors, both external and internal to companies, that can be regarded as main barriers in adopting resource wise strategies in SMEs.

4.1 Barriers to resource wisdom

Previous studies have shown that SMEs are increasingly aware of the benefits of improving resource efficiency. Saving material costs and creating competitive advantages are seen to be the most interesting benefits for SMEs. (Rizos *et al.*, 2016, p. 4) Despite the perceived benefits, SMEs face various challenges in their efforts to improve resource efficiency. Trianni et al (2014, p. 1254) found that SMEs' experience barriers in increasing energy efficiency mainly in the first phases of the process (identifying opportunities, raising awareness, identifying technology, and action planning). In addition, smaller companies experienced the major difficulties also in implementing the actions, which may indicate the lack of expertise and knowledge in SMEs.

The Rewise study identified barriers to resource wisdom related to four main themes: organisational, customer, supply network and institutional barriers. Organisational barriers are internal ones, customer and supply network barriers relate to company's business environment, and institutional barriers relate to legislation and other external factors. These barriers (Table 1) are discussed in detail in this section.

Table 1. Main barriers based on previous research

4.1.1 Organizational barriers

The company's culture, values, and environmental attitude refer to the company's views on green, ecological, and environmentally friendly business, including the philosophy, habits, and attitudes of the company's manager and employees. (Meqdadi, Johnsen and Johnsen, 2012; Bastein et al., 2014; Rizos et al., 2015, 2016) Rizos et al (2015) emphasize the importance of the personal values of the manager in SMEs. Because the manager is usually also the owner of the company, his or her attitude and values significantly influence the company's strategic decisions. This was also mentioned in Rewise interviews, where one company manager explained his role as a role model for employees.

> *"According to my own values, natural resources should not be wasted and the environment is important. The goal is to do everything (environmental issues) that makes sense for us to do. I regard it important that I, as CEO, have the (positive) attitude. We e.g. recycle cardboard, even if it costs us but we do it because we think it's right thing to do."*

Lack of knowledge, information and competencies are identified as central barrier in many studies. (Meqdadi, Johnsen and Johnsen, 2012; European Commission, 2016; Rizos et al., 2016; Tura et al., 2019; SDA Bocconi School of Management, 2021) Environmental consideration and improvements require time and human resources which many SMEs do not have. (Meqdadi, Johnsen and Johnsen, 2012) SMEs' shortage of time and human resources was also discussed in Rewise interviews. Lack of human resources as well as lack of language and ICT skills were mentioned as obstacles in implementing resource wise activities.

> *"This (environment) is the last thing in the priority list to consider. Small businesses do not have the human resources to consider such matters."*

> *"From the perspective of human resource efficiency, language skills and the basic level of ICT knowledge create a limit where we can operate. There would be staff available who could do it, but people just can't be changed. One should get the current employees to learn new systems. There is a learning challenge."*

Many SMEs do not have capability to invest time or money in environmental initiatives. (Meqdadi, Johnsen and Johnsen, 2012; Bastein *et al.*, 2014; Tura *et al.*, 2019) Balancing with limited resources and the resource wise development was mentioned in one interview.

> *"Some customers are pushing us a little bit more. Most of them are not interested at all. As an SME, we have to know where is the limit. We do not have resources to do a lot. We have to do enough in order to be competitive."*

According to Bastein et al. (2014, p. 41) SMEs often experience barriers when increasing their resource efficiency "due to a lack of information and knowledge of alternative technologies, materials or practices". Many SMEs do not have the technical capacity to identify, assess and implement more advanced technical options that would enable them to reduce the environmental impacts while realising cost savings. (Rizos et al., 2015) In Rewise interviews, one business executive discussed the role of new technology in implementing resource-wise operations. It seems that new technology is considered more resource wise than the old one.

> *"Of course, the purpose of the business is to make a profit for the owners. It is money that really matters. Companies rarely make investments that lead to more expensive solution than the previous one just because it is more resource efficient. However, the great thing is that it (new technology) almost always includes both perspectives."*

In Rewise interviews, many SMEs mentioned that they do not have enough information and knowledge about resource-wise activities. In addition, resources for developing resource wisdom are very limited, as one company concretely described:

> *"The problem with SMEs is that we are so deep in this daily business and we don't have time and we don't understand the need of this helicopter perspective. It is totally different thing in bigger companies that have resources and own groups who can make plans and visions and so on. If we can make goals for the next year, we have done much. This is the problem. As we are swimming in this daily mud, we don't see the sea."*

The lack of good business cases describing the development of resource wisdom and its benefits and application areas was seen as an obstacle to launching resource-wise operations. Many of the publicly available business cases concern large multinationals, which are often difficult for SMEs to identify with.

> *"I have found that examples and training are often aimed at large companies. When we go down the supply chain to the supplier's supplier, then there is less expertise to understand what it means to them. It would be appreciated if the debate would seek to highlight more concrete things like what resource efficiency means in practice. It would probably help to increase the understanding."*

Grevenstette (2016) reported that many SMEs had faced difficulties in choosing the right resource efficiency actions for their company. The need for SME specific instructions and guide books was also mentioned in Rewise interviews.

> *"Written instructions are needed on how to become resource wise. So that it is not up to the companies themselves to decide. The resource wisdom is the last thing we start to think about. Unless we are forced to do so."*

The study of European Commission (2016) found that SMEs are often not fully aware of the long-term advantages of resource efficiency. The impact of material and energy-saving related to their operations is not measured either. Many of the interviewed SMEs had environmental quality certificate or other environmental quality system. One executive manager explained that meeting the environmental requirements is the hardest task in the Twhole quality system.

> *"The most difficult part of a quality system is when it comes to the environment. Last year, an auditor pointed out that environmental considerations and targets should be updated. However, measuring these targets is difficult."*

Companies identified the lack of a holistic view as a challenge to resource-wise operations. The lack of a holistic view within the company is reflected in the fact that resource wisdom is not managed as a strategic entity but consists of separate cost-saving measures in the different functions of the company.

In general, many of the interviewed companies focused heavily on minimizing waste in their internal operations. The main goal of minimizing waste was to reduce costs and thereby improve profitability. SMEs consider waste hunting to be useful and profitable, but its significance on a larger scale and especially for the environment, still remains unclear.

4.1.2 Customer related barriers

The lack of customers' environmental awareness and demand in market are widely seen as a barrier for increasing sustainability in companies (Meqdadi, Johnsen and Johnsen, 2012; Bastein *et al.*, 2014; Rizos *et al.*, 2015, 2016; European Commission, 2016; SDA Bocconi School of Management, 2021). Even though sustainable awareness has increased among companies, many SMEs reported that sustainability has not fully entered into the way of doing business yet. However, companies need to think primarily about their company's finances, in which case any charity or 'saving the world' is out of the question.

> *"The change in general attitude is moving in a more responsible direction. At the moment, however, it is primarily money that matters. If you try to save the world alone, your business will die before the world is saved. You need to keep your business alive."*

In Rewise interviews, one of the most frequently mentioned challenge was that customers do not value resource wisdom in their purchasing decisions. One company even described how they have introduced technology that promotes ecological goals, but customers don't appreciate it.

> *"I believe that the value to our customer comes from the most productive product possible. The industry in general has been forced to implement expensive technology that our customers really do not see any value."*

The ecological issues may influence purchasing decisions to some extent, but they are usually not among the most important issues. Bastein et al. (2014, p. 39) found that if customers are not prepared to pay any premium for green products, the market demand will be weak. This is in line with the findings in the Rewise interviews.

> *"We could do a lot more, but since it is business, we just have to do the things that someone is willing to pay for. Even if we have a thousand times better ideas, it is too early to implement them if no one is willing to pay for them."*

Based on the Rewise interviews, it seems that in general, price is still unequivocally the most important purchasing criteria. It is clear that the prevailing short-term thinking is detrimental to all initiatives to develop resource efficiency. From the customers' side, short contracts, recurring offers, finding the lowest purchase price, are all attempts to get immediate economic benefits.

These attempts often conflict with the resource wise activities which require collaboration and wider perspective.

Also, the need for mindset change was identified in customers operations. In the Rewise interviews, several SMEs explained that they had advanced know-how, technology or a business model that they could not take full advantage of due to the client's rigid practices. As an example of these kind of rigid practices, it was mentioned that customers are counting costs in a traditional way, which do not consider life cycle costs. Companies had also identified that their customers lack competence or willingness to count costs in a way that favours also environmental aims.

> *"One of the biggest obstacles is that people's minds are still in boxes. They don't see the entire supply chain or the entire lifecycle of the product. We still see partial optimization almost every day. It's very difficult for a customer to decide on something that might be more expensive to buy, but if you look at the whole lifecycle or supply chain, it is cheaper or creates less cost or uses less resources."*

In particular, SMEs operating as subcontractors for large corporations, experienced their influence was very limited. Many of the interviewed SMEs pointed out that big multinational customers do not always appreciate or are willing to utilize the full potential of the knowledge and expertise that SMEs can offer.

> *"We have to coordinate the communication with many actors. Sometimes there are difficulties in communication and with hierarchy. It is sometimes difficult to communicate that we can support the customer (with our knowledge). Even we are a small company, we can help customers' business in that specific narrow segment that we operate."*

> *"We try to instruct customers to design the product differently. Customers may not always understand why we are proposing changes or proposing new approaches to manufacturing. This requires skilled people. There is a need for people, who are really willing to do things in a new way and question old practices."*

4.1.3 SUPPLY NETWORK BARRIERS

Previous literature has identified several supply network related barriers such as mistrust and confidentiality between partners (Meqdadi, Johnsen and Johnsen, 2012), lack of collaboration and resources (Tura *et al.*, 2019) and lack of support from the supply network (Rizos *et al.*, 2016).

Many of the interviewed SMEs stated that their industry is traditional and therefore resource wisdom is not yet a topic in business discussions. It seems that large customer companies usually

require suppliers to have an environmental certificate. Otherwise, it is enough to meet the requirements of the law.

Selecting suppliers, materials and transportation modes (Carter and Easton, 2011; Meqdadi, Johnsen and Johnsen, 2012) are important decisions when thinking about resource wisdom. Based on the Rewise interviews it seems that when choosing their suppliers, SMEs do not assess the commitment of potential partner to resource wisdom. Cost, quality and security of supply are at the forefront of the selection criteria. Because there is no general emphasis on resource wisdom or sustainability in corporate communications, it also makes it difficult to assess how committed a potential business partner is to resource-wise practices. However, the close proximity of critical suppliers was seen to have strategic meaning for many interviewed SMEs.

> *"We do not select suppliers based on ecological issues. Normally it is that if we have good relationships with some supplier, we use it (standard part supplier or subcontractor). We use quite common purchasing terms. There is nothing special."*

> *"When choosing suppliers, the priorities are quality, security of supply and price. That is, resource wisdom is not paramount in the mind. In addition, the number of suppliers is quite limited, and requires a major investment to take a new supplier into the supply chain."*

Therefore it seems that "green purchasing", defined by Wooi & Zailani (2010, p. 22) as "purchasing or supply chain managers consider the issue of sustainability in their purchasing of inputs", is not yet an issue in interviewed SMEs.

> *"In the value chain, values must meet. Resource wisdom should be a big criterion when choosing partners. Before you get into it, the general atmosphere needs to change a bit more. It is still not much discussed when choosing partners."*

Resource wisdom involves looking at the use of resources throughout the value chain and product life cycle, which is another implication of holistic view. Bastein et al. (2014, p. 25) explain that "The redesign of a product or service allows the entire life cycle and value chain to be taken into consideration. This includes not only processes within the company but also involves suppliers and other stakeholders in the value chain of the product or service."

Previous research has identified that SMEs may find themselves in a difficult situation between their customers and their suppliers. Due to their small size and bargaining power, SMEs' have only limited possibilities to influence on their suppliers' engagement in sustainability activities. (Wooi and Zailani, 2010; Rizos *et al.*, 2015) Meqdadi et al. (2012) found that SMEs "face a dilemma of adopting sustainability requirements posed by their larger customers and at the same time

transferring these requirements to their own suppliers. As they lack resources, skills and bargaining power, SMEs face difficulties to engage and seek cooperation of their suppliers in implementing sustainability activities." This dilemma was described also by some SMEs in the Rewise interviews. For example, one company found that their suppliers could do many things to increase the resource efficiency. However, the SME had noticed that suppliers' resource efficiency is out of their reach, because they are only one small customer to supplier.

In the Rewise study, many SMEs considered the resource-efficient value chain and product life cycle to be important, albeit very difficult to achieve. The interviewed companies were talking about 'holistic view, helicopter perspective and understanding the whole'.

> *"Utilizing resource wisdom requires holistic and competent management of the whole. This requires an understanding of the entire life cycle of the product."*

At the moment, many companies focused on life cycle stages which they feel to be directly in their own control. Companies reported, for example, that they do not have contact with the client's client. Therefore, the life cycle stages of the product after manufacturing seemed to be beyond their reach.

> *"We do not think about the life cycle effects of a product, as we cannot influence them. But if it were possible to influence them, there would certainly be an effort to influence them."*

> *"We have no information on the environmental impact of using the product. We do not have such discussions."*

Many interviewed companies also saw that other companies have bigger possibilities to increase resource wisdom in the value chain.

> *"Most potential for increasing resource wisdom is probably in suppliers' and their suppliers' operations. In addition, there are also development opportunities in the customers' operations."*

> *"Resources are wasted in tremendous hustle. Then, it does not matter whether the environment is burdened or what the costs are. The production chain should be realistic. You should be able to do what you are going to do, load the trucks full etc. This would save both nerves and the environment."*

The product life-cycle approach brings a large number of actors to the same table, which inevitably makes cooperation complicated. In addition, a lot of questions arise. How can we involve all relevant actors? Who does understand the big picture and who will take the lead in the development? How are the benefits and costs shared? This is well in line with Bastein et al. (2014, p. 39) who have

noted that resource wisdom is challenged by the need for complete networks of actors to work together towards resource-efficient processes or products.

Due to their size and available resources, SMEs are often forced to stay in observing role in relation to the trends in the market and a value chain. (Rizos *et al.*, 2016, p. 2) This is in line with findings in Rewise interviews. Although resource wisdom was considered important, SMEs mainly took the role of follower in the market, which can be seen in the following comments.

> *"Legislation can come later but companies are the key actors. We have to be eyes open what (other) companies are doing. We are not going first but if some big company gives good example and it looks like customers have demand, we need to follow but as a small company we are not doing all the things first. We are following market needs and case by case if someone asks more, we do what they want."*

> *"It starts with big companies. They put pressure on us, subcontractors and contract manufacturers. They have the resources."*

Bastain et al (2014, p. 41) reported that the lack of R&D resources as well as the scarce resources for building partner networks can become barriers for resource efficient operation. Also, in Rewise interviews, the lack of R&D resources and partners were mentioned as a barrier for resource wisdom especially in the field of material development. In this case, the company did not have resources and knowledge to do the development alone but the large customer company was not interested enough to invest in the joint development.

> *"We should test and make some plans and combine different materials more than we do today. But our partners are not so keen to find new solutions on that field."*

This is well in line with Bastein et al. (2014, p. 39) who noted that resource efficiency is challenged by the need for complete networks of actors to work together towards resource-efficient processes or products. Unfortunately, it is common that actors have differences in their level of innovativeness and risk-taking capabilities. In Rewise interviews, one executive manager described the frustrating situation in the market.

> *"New things that are absolutely essential in energy efficiency and resource wisdom require changes in current practices. Too many companies, influencers, lawyers and others are startled and say that this cannot be done, at least on this timetable. Too many things change. They want time to think. Therefore, these things are not progressing."*

However, if companies find a common goal and the means to achieve it, the supply chain can reach competitive advantage. In Rewise interviews, one subcontractor explained how minimizing the material usage of the product crates joint benefits with their customer.

> *"We are constantly working to reduce the waste rate. If material savings are obtained, it has a direct effect on the product price. We are working to ensure that our customers can use less material and that their situation is stronger because they are able to sell cheaper."*

4.1.4 Institutional barriers

Bastein et al. (2014, p. 24) define institutional barriers to include things such as environmental policy and enforcement of regulations, incentives, anticipated legislation and access to grants and subsidies. In Rewise interviews, the legislation and various environmental regulations were seen ambiguously. Most companies felt that current legislation did not provide an incentive to put resource wisdom into practice. However, for some companies, EU environmental targets proved to be a major challenge and required companies to invest heavily in product development.

> *"The legislation is the number one. They are the frames where we have to work and adapt our product. Also, political plans and visions, have impact on the industry. We can see also quite big changes during the periods who are in power. Longer plans would be better for the whole industry."*

> *"The industry has been forced to implement and even develop really expensive technology that our customers really do not see any value. This has been a huge burden for the industry. And the smaller the company is, the more difficult it actually is to hit all of these requirements. This is very much hindering the development of those things that really matters to our customer."*

Many of the companies also stated that resource wisdom is not sufficiently encouraged and rewarded by the public sector. Companies described how they see that in some cases, differences in environmental taxes and legislation can distort the competition in the global market.

> *"If we take, for example, a material that can be made either in Finland, the Baltic countries or Poland. If the oil is cheap, so is the transportation. In this case, the material imported from abroad is also cheaper. It is cheap because environmental fees are not paid from transportation. Our price level in Finland is what it is and you have to buy the cheapest one without considering what has happened before the material is here."*

However, one interviewed company mentioned that they have already noticed some changes in their field of business. Environmental issues are required by the financial institutions in order to get financing.

"All the aspects of environmental issues are considered more and more. We already know that some companies that are not taking environment and other aspects into account don't get a loan. I mean multinational companies."

4.2 Conclusions

Based on interviews with manufacturing SMEs in Ostrobothnia, it seems that companies are already doing a lot to promote resource wisdom. Optimizing the use of raw materials, energy and time serves the goals of resource wisdom. However, the use of methods and calculations (eg. LCA or LCC) could facilitate the assessment of the effectiveness of actions from an ecological point of view. This would probably reveal entirely new forms of development activities. The verified information could also be used in sales and marketing.

At the value chain level, resource wisdom requires a significant change in thinking and ways of working. Sufficient pressure is needed to move from the "every company should take care of its own plot" approach to the "together we come up with a wiser solution". This requires a sufficiently far-reaching change in attitudes, values and practices.

Valuing and leveraging external expertise in developing resource-wise solutions is the first step. The second step could be a joint development project to achieve a resource-wise production chain. As a result, customers would get more resource-wise solutions. Possibly even cheaper than current solutions.

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5. Resource wice practices

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This article presents resource wise practices identified in academic literature and describes which resource wise practices are already implemented in SMEs.

5.1 Resource wise practices in academic literature

The academic literature has acknowledged and explored various resource-wise practices. As the term "resource wisdom" is not much referred to in the literature, this article will analyze practices in the areas of energy efficiency, resource-efficiency, and circular economy, which are considered resource-wise activities. The identified practices are presented in the LCA (life cycle analysis) stages to form a holistic overview of resource wisdom and uncover development possibilities. The LCA process stages are product planning and design, raw material acquisition and internal logistics, production, delivery and logistics, use, and EoL (end-of-life). The typical issue is determining and establishing resource-wise practices that have a practical value and are eligible for implementation.

5.1.1 Circular economy related practices

Circular economy (CE) refers to a loop economy which is replacing a linear business model. CE emphasizes waste avoidance, resource-efficiency and resource dematerialization which characterize resource wisdom. Restorative and regenerative industries are at the center of CE. (Bockholt, Hemdrup Kristensen, Colli, Meulengracht Jensen & Vejrum Wæhrens 2020). Corresponding practices distribute quite equally to the LCA process, but raw material acquisition, production, and EoL are emphasized.

Recycling and reuse of materials and components have a significant role in a CE business model. Several scholars emphasize the positive effect of recycling and reuse on waste reduction, resource efficiency, and other circularity objectives. (Bockholt et al. 2020; Ingarao, Zaheer, Campanella & Fratini 2020; Paletta, Filho, Balogun, Foschi & Bonoli 2019). Considering the LCA process, most recycling opportunities are located in raw material acquisition, production, and EoL stages. Companies often generate resource waste during raw material acquisition and production, and particularly within industrial manufacturing companies, waste of metals is typical. The capacities for utilization of these side streams and overflows are increasing in societies, and thus, recycling of raw materials should be strongly encouraged. Companies can recycle materials properly and take

advantage of waste side stream possibilities if they have sufficient knowledge and technical capabilities. The managerial level can, for instance, enhance organizational commitment by providing instructions and organizing workshops for recycling and reuse. (Bockholt et al. 2020; Ingarao et al. 2020).

At the EoL stage, products' circularity can be increased through recycling, remanufacturing, and reusing. EoL components are often recyclable, but their users are not aware of it. This problem can be reduced by informing customers about the recycling capabilities at the purchase moment and when disposal is approaching (Ingarao et al. 2020). Besides, reusing EoL products has grown the interest among companies for potential economic advantages. It is suggested that taking-back products from customers is a suitable strategy for evaluating reuse possibilities. This method's core is that manufacturing companies take responsibility for EoL products and decide whether the products can be reused or remanufactured and, if not, dispose of them properly.

However, identification of reuse and remanufacture purposes requires deep industry-related and technical knowledge from a sustainability perspective. Lack of this knowledge is a significant barrier in pursuing reuse and remanufacture strategies. Moreover, this perspective does not consider costs generated from additional logistics and resources needed for remanufacture processes. The discussed cost benefits are from the raw material acquisition savings, but a more holistic research about total costs is required. (Bockholt et a. 2020; Garza-Reyes, Salome Valls, Nadeem, Anosike & Kumar 2018).

To further continue with the reuse mentality, several other practices companies can do that help to decrease fast disposal of products while supporting the transition towards a society of reduced consumption. Considering the use stage in the LCA process, the longevity of usage is affected by the decisions and actions made earlier in a manufacturing process. For instance, choosing high-quality materials prevents arising problems with a product during its usage, and companies can estimate a longer life cycle which is, resources considered, profitable. It is necessary to invest in product planning and design, including mapping suppliers and conducting LCA calculations of alternative propositions. Hiring a sustainability expert is, in some cases, crucial for conducting these analyses. (Garza-Reyes et al. 2018; Millar & Russell 2011).

Additionally, it has become quite typical for businesses to adopt PSS (product-service system) strategies, and during recent years, the manufacturing industry is shifting towards this ecosystem. PSS strategy emphasizes service orientation in business modeling: traditional selling of products is being replaced with providing comprehensive solutions through services. (Ünal, Urbinati & Chiaroni 2019). Servitized business model aims to increase customer attraction with additional services and benefits.

Upgrading and repairing of products during different life cycle stages are instances of such services. These services support CE's objectives by extending product life cycles, saving resources, and reducing the need for purchasing new. (Ingarao et al. 2020.) Besides, leasing of products is a general cost model in service-orientated businesses. It has sustainable advantages because it enables the manufacturer's return of products who can lease them to other customers, remanufacture them, or transfer materials to reuse. Moreover, research and development of commercialization strategies for remanufactured products would enhance their application and improve the circularity of products and raw materials. (Bockholt et al. 2020).

5.1.2 Resource efficient practices

Academic literature has recognized few strategies that enhance resource-efficiency and decrease resource consumption. The strategies are additive manufacturing and commerzialisation of remanufactured alternators. The limitations of these strategies are that they have been analyzed focusing mainly on large enterprises and the applicability may differ with SMEs. The existing skills, technology, and resources of SMEs are necessarily not adequate, which means they need more consulting and support for their application. (González-Varona, Poza, Acebes, Villafáñez, Pajares, López-Paredes 2020; Fatimah, Biswas, Mazhar, Islam 2013). Governmental assistance, especially receiving consulting services and subsidies, correlates positively with a higher resource-efficiency level within companies (Fadly 2020).

A business model that focuses on sustainable spare part logistics is a new method for extending product life cycles in an eco-friendly way. Sustainable spare part logistics is referred to additive manufacturing which derives from the invention of 3D printing. 3D printing of spare parts is the most significant factor in achieving sustainability benefits from additive manufacturing; it minimizes the need to transport materials and products and reduces logistics costs. The additive manufacturing business model requires either individual 3D printers for customers or the establishment of local 3D printing operators. 3D printing enables the development of a digital supply chain, which can be defined as a supply chain in which the manufacturing data can be transferred through a digital network from one facility to another more effectively and without burdening the environment. Waste generation of additive manufacturing is mainly from unexpected defects or auxiliary materials. However, it has massive potential for more sustainable supply chain logistics and attaining energy and raw material savings, making it an environmentally benign practice for manufacturing companies. (González-Varona et al. 2020).

Another critical strategy for resource-efficiency is remanufacturing because it maximizes the use of components and avoids the excessive generation of landfills and energy usage. Advanced planning and budgeting are at the core of successful remanufacturing because extending EoL

require finding alternating objectives for components. Academia suggests exploring the business model potentials of remanufactured alternators. The alternator is a part of an automotive component that can be remanufactured for other purposes and thus, improves resource circularity.

However, the field of remanufacturing has been relatively unexplored, and practical suggestions limited. From an organizational point of view, remanufactured alternators should provide viability in both economic and environmental sense to be beneficial. Utilizing recycled components for the remanufactured alternators could help achieve desired sustainability results since it offers approximately 50 percent cheaper costs and less material consumption than new products. (Fatimah et al. 2013). However, the additional costs regarding the collection and logistics of recycled components are not considered, and they may yet influence on results.

Table 2 presents the main findings of the practices addressed in the academic literature. The practices have been categorized to energy efficiency, CE, and resource-efficiency, and included to a corresponding stage of the LCA process. As Table 1 shows, energy-efficient practices are the most limited considering the stages of the LCA process.

	Energy efficiency	CE	Resource-efficiency
Product planning and design	Advance planning of volumes, processes, and internal logistics Purchasing modern technology	Developing capabilities to exploit waste side streams	Planning with less resources Planning alternators for products
Raw material acquisition		Utilizing recycled materials Recycling waste material	Acquiring remanufactured components
Production	Implementing AI based platforms Optimizing buildings (e.g. HVAC) Regular monitor and evaluation	Recycling production waste Organizational workshops and instructions from managers	Avoiding excessive generation of landfills
Logistics			3D printing
Use		Products have a long life cycle (e.g. using high-quality materials/providing life cycle services)	3D printing Implementation without excessive resources
EoL		Products are recyclable/reusable Take-back strategy	Transferring alternators to other purposes

Table 2 Main findings of the practices addressed in the academic literature

5.2 What practices have the interviewed SMEs adopted?

According to the interviewed SMEs, the adopted resource-wise practices mainly relate to the production and product features. The emphasis of practices is clearly in the beginning stages of the LCA process: product development, raw materials, and production. The interviews addressed an issue that many SMEs do not have any data about the sustainability activities in the use and EoL stages. Figure 4 presents an illustrative overview of the practices mentioned by the SMEs.

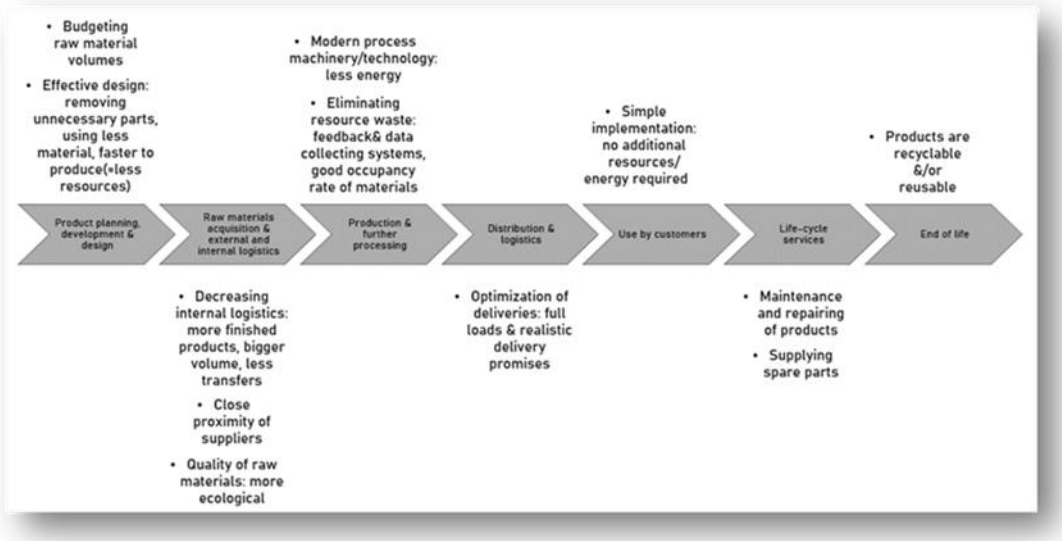

Figure 4 Overview of the practices mentioned by the SMEs

LCA process begins with a product planning and design stage. Current sustainable principles are related to the avoidance of excessive resource consumption and waste generation. It is executed with careful budgeting of raw material volumes in advance and designing products focusing on future perspectives, which means longer product life cycles. This aim is achieved, for instance, by using quality materials and further analyzing customer preferences and industry trends. Besides, new technology and innovations enable companies to plan manufacturing processes more efficiently and energy-saving.

> *"Our goal is to design products that are efficiently manufactured and easy to use. Efficiency in manufacturing means quick and easy use as well as product maintenance and repair to avoid short life cycles."*

Following is raw material acquisition and internal logistics of the LCA process. These activities are strongly influenced by the decisions in product planning and design. Sustainable practices that the case companies are considering are the ecological nature of raw materials and purchasing from closely located suppliers. However, the significance of sustainable criterion in raw material acquisition depends on customer's valuation and cost factors for SMEs.

"We consider the quality and cost of raw materials as well as logistics. The goal is to buy quality material that is better for the environment and customers. However, we can find cheaper material in Europe, but importing it can cost and pollute more. Logistics and quality need to be assessed in this situation, but in general, less cost and resources means more sustainability."

Regarding the production stage, the current sustainable practices consist of optimizing machinery and decreasing all resource usage and wastes. The case SMEs are non-energy intensive, but they mentioned that sustainable practices in production mainly aim to reduce energy usage and improve energy-efficiency. This goal can be achieved with various data collecting and feedback systems which helps companies perform changes based on analytical and reliable information.

"We have different policies and feedback systems that we use to collect data and reduce waste. This helps to uncover problems in the manufacturing process, which are then solved in product design."

The delivery and logistics stage follow the production stage in the LCA process. The results mainly address that sustainability comes from optimizing logistics which refers to volumes, scheduling, and routes. Most of the resource waste generates from the hurry and unexpected situations, which are attempted to avoid.

"We optimize logistics by always driving at full load. Avoiding urgencies in a supply chain decreases waste generation and is, therefore, good for environment."

When discussing the use and EoL stages, it became clear that the case companies do not have significant sustainable practices activities. It was stated many times that they often do not have the required data or effect on these LCA stages, and there is a lack of customer communication, so sustainability is not much considered in the usage and disposal. The practices mentioned in the use stage enable easy implementation for customers, which means not utilizing unnecessary resources for the process. Besides, companies attain to manufacture products with extended life cycles, which is affected strongly by product planning since quality and product features determine this a lot. Regarding EoL, the current practice is manufacturing products which components and materials are recyclable and reusable. The general issue is that the case companies do not know whether the products are recycled or reused. However, considering the scarcity of resources among SMEs, it is understandable that resource-wisdom is not much regarded in the EoL stage.

"We do not have conversations with end-customers about the environmental sustainability in the use stage. Products are probably recyclable at EoL"

"We do not have influence on the use stage when our products are with customers. How-ever, all the materials in our products are recyclable and

reusable, and the design is developed with a focus on resource-efficiency which hopefully is beneficial in the usage."

Life cycle services are a significant factor in avoiding early disposal and resource consumption due to product replacement. Many of the case companies provide maintenance and repair services or sell spare parts for their products which serves the CE principle of maximizing the utilization of resources. Moreover, this applies to the service-based business model and enhances customer loyalty and long-term relations.

> *"We supply spare parts for our products to customers which is a sustainable practice since it decreases the need for purchasing new."*

> *"We have a product maintenance and repair service which extends resource usage potential."*

5.3 Future insight of sustainable practices according to the interviewed SMEs

In the future, the SMEs consider that life cycle perspective and CE will define manufacturing industry. Calculation of life cycle costs, sharing platforms, and circular resource streams will develop and new business opportunities will be established. The SMEs also addressed the need for more efficient local recycling systems, and said how there are regional differences for sustainable opportunities which should be equalized in the near future.

Additionally, technological advancement will enable 3D printing which reduces resource consumption and waste significantly. 3D printing requires new expertise for product design and development, which is not present in Finland at the moment. Technology and "Clean Tech" innovations will enhance sustainable manufacturing a lot. In addition, it will be critical to have the mentality for sustainability embedded into each organizational level.

The results address that collaborations have a prominent enhancing impact on the sustainable ecosystem. The discussions included various instances of collaboration possibilities. Firstly, collaboration with other businesses in a form of partnerships or sharing platforms have a potential for mutual resource advantage. Secondly, knowledge sharing among industries could help designing sustainable supply chains. Digitalization provides several applications for effective communication despite the location or time constraints. Thirdly, cooperation with universities and other research facilities is considered beneficial. Participation in research ventures supports the development of organizational knowledge and capabilities with reasonable resource utilization.

Circular economy business models will develop in general, and sharing of resources will become more common. Resource efficiency will develop in collecting and utilizing waste energy/heat. In addition, locally I am hoping for better material recycling systems and services.

The conception of cost will get broader in the future including life cycle and sustainability aspects. Preservation of nature will have an essential role in every business.

5.4 Conclusions

Resource wisdom in industrial SMEs is defined as decreasing total energy and resource consumption, enhancing circularity of materials and products, and avoiding waste generation by integrating measures that support these objectives. The academic literature has identified several practices throughout the LCA process which relate to energy efficiency, CE, and resource-efficiency. The empirical results also show that some of these practices have been implemented to business. Many of the tangible practices locate to the product planning and design, raw material acquisition, and production stages of the LCA process. At EoL, the suggested resource-wise practice is mainly producing recyclable and reusable products. The take-back strategy is also mentioned but it will need more research.

It is stated that sustainable activities should become more fundamentally integrated to business models to attain permanent progress. Traditional structures are considered as deficient for sustainability requirements in the academic literature. Furthermore, this indicates a need to the creation of a new sustainable ecosystem in industrial manufacturing. The empirical results also support this view by stating the need for a collective supply chain development and addressing the existing industry-related obstacles that are heavily structural.

Further research could assess the possibilities of industrial networks and sharing platforms. Networking and sharing of resources are recognized as a significant contributor to CE strategies, and tangible measures could facilitate this transition. Another interesting topic for the future is the commercialization strategies for remanufactured products and recycled materials and components. This could increase taking-back products, and lead to better utilization of resources.

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6. Summary: Resource wisdom in manufacturing SMEs

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This collection of articles aims to introduce resource wisdom to manufacturing SMEs. The report also investigates the meaning and current state of resource wisdom in SMEs in Ostrobothnia region in Finland.

This report introduces the concept of resource wisdom as a "wise use of natural resources, materials, and energy following sustainable development and circular economy principles". At the moment, many SMEs seem to associate resource wisdom to familiar themes such as recycling, reducing the carbon footprint, efficient use of materials, and energy efficiency. What many SMEs have in common is that they see resource wisdom to have an important role in improving economic performance through cost savings.

This report also investigates what is hindering SMEs in implementing resource wise activities. For understanding these challenges faced by the SMEs, this report presents the previous studies related to the barriers of resource wisdom as well as results of the interviews with SMEs. Barriers for implementing resource wise activities seem to relate to four main themes: organisational, customer, supply network and institutional sources. Organisational barriers are internal ones, customer and supply network barriers relate to company's business environment, and institutional barriers relate to legislation and other external factors.

Academic literature has identified several resource-wise practices. This report summarizes the practices identified in the LCA (Life Cycle Analysis) phases to provide a comprehensive overview of resource wise practices and to uncover opportunities for improvement. Resource wise practices in academic literature relate mainly to energy efficiency, circular economy, and resource efficiency. Company interviews showed that in SMEs, many concrete resource wise practices focused on product planning and design, sourcing of raw materials, and production. On the other hand, companies found practices in the EoL stage quite complicated.