Information Sharing in Industrial Symbiosis

Anne-Mari Järvenpää[1(✉)], Jussi Kantola[2,3], and Vesa Salminen[1]

[1] Häme University of Applied Sciences, Hämeenlinna, Finland
anne-mari.jarvenpaa@hamk.fi
[2] Department of Mechanical and Materials Engineering, University of Turku, Turku, Finland
[3] Faculty of Engineering Management, Poznan University of Technology, Poznan, Poland

Abstract. Industrial Symbiosis is a way to implement Circular Economy, by connecting industrial waste as an input for another industrial process. These circular material flows have an important role to sustainable development. Earlier research shows that there is lack of information related to waste and by-products, that brings challenges to logistics and managing sufficient input for production. There is a gap in the knowledge of information sharing in ongoing and long-term Industrial Symbiosis. This paper presents a case of biobased Industrial Symbiosis with one by-product producer and three by-product producers and seeks answers to how information is shared between companies.

Keywords: Industrial symbiosis · Circular economy · Information sharing

1 Introduction

Circular economy plays a big role for the sustainable future driven by resource scarcity, growing consumption and amount of waste. Circular economy reduces the consumption of virgin materials and aims to keep materials in use longer. Industrial symbiosis is a concept that implements circular economy by connecting industrial waste or by-products as a raw material for another industrial actor.

Earlier research shows that there is lack of information related to waste and by-products, that brings challenges to logistics and managing sufficient input for production. However, there is research literature and new solutions that serve as material sharing platforms, connecting the supply and demand. Nevertheless, these solutions are applicable when company is looking for a partner to supply or receive materials. These sharing platforms or marketplaces do not serve a long-term business relationship. Digital technologies are expected to solve information sharing challenges, by connecting waste producers, logistics partners and waste utilizers providing information for decision-making.

There is a gap in the knowledge of information sharing in ongoing and long-term Industrial Symbiosis. To fill the gap this research seeks answers to the questions of 1) how information flows in Industrial Symbiosis and what are the gaps and discontinuities, 2) what is the value potential of missing information and what are barriers and opportunities to share or obtain it and 3) how companies see the role of digitalization in the development of Industrial Symbiosis and are they willing to take advantage of it.

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2021
J. I. Kantola et al. (Eds.): AHFE 2021, LNNS 267, pp. 79–85, 2021.
https://doi.org/10.1007/978-3-030-80876-1_12

This research is conducted in Finland as a qualitative case study. This paper introduces a case of biobased Industrial Symbiosis with one by-product producer and three by-product producers. Research data was gathered by interviews on January 2021.

2 Theoretical Background

Industrial Symbiosis research has produced information about the drivers and barriers for Industrial Symbiosis [1–4]. One central finding is information related barrier which includes finding suitable partner and achieving information about the availability of waste and by-products. There are researches about online sharing platforms and how applicable they are, and on the other hand, suggestions how they should be implemented [5–7]. Main idea with these platforms is matchmaking, connecting waste producers and waste users with the help of matchmaking algorithm. But when long-term industrial symbiosis relationship is established and the problem is to share material related information, e.g. availability, a matchmaking platform is not the solution.

2.1 Drivers and Barriers for Industrial Symbiosis

Establishing Industrial Symbiosis requires finding suitable partners in order to connect material supply and demand. Waste management and recycling companies could have an important role to develop circular material systems. Manufacturing companies are facing growing needs to show their sustainability and responsibility in environmental aspects [2, 8].

There is high potential for Industrial Symbiosis in Europe's manufacturing sector, but the barriers related to lack of trust, unwillingness to share data and insufficient waste flows must be solved [9]. There is a need to raise awareness of Industrial Symbiosis practices and business models for both, waste producer and waste user [10], and to innovate something new. Important elements for collaboration are trust, joint problem solving, information transfer and shared vision [11]. Key conditions for circular material flows are logistics, sufficient volumes, market demand and quality guarantee [12]. Drivers to realize the key conditions are mobilizing power by change agents, co-operation within the material chain and information exchange.

Research has pointed out that financial issues are both, the main driver and the main barrier to inter-organizational collaboration [11]. The biggest driver for Circular Economy relates to regulatory or institutional factors while the biggest barriers are technical [13]. Transition from linear to circular can be hindered by material characteristics, processing technology, supply chain issues, organizational factors, external drivers, the public perception of the current situation and economic viability [14].

2.2 Information Sharing in Circular Economy

Different tools has been proposed for the identification of potential partners and synergies [15–19] or to model Industrial Symbiosis systems [20]. However, there is lack of knowledge how information is shared in ongoing Industrial Symbiosis.

There are two reasons not to share information: unwillingness and inability [21]. Cervo et al. highlights the barriers of exchange confidential data between organizations and provides a methodology build the profiles by required data [22]. But there is no knowledge which information companies consider to be sensitive [21].

2.3 Information Flows in Circular Economy

Kurilova-Palisaitiene et al. [23] explored product life-cycle information flows to support remanufacturing, identified constraints for efficient information flows and visualized the information losses and bottlenecks. For future research they pointed out the questions of: what information is valuable, how and how frequently information should reach the receiver and what information would add value for stakeholders?

2.4 Digitalization and Circular Economy

Kerdlap et al. says that IoT technologies should be applied to connect waste generators, collectors and converters as a system facilitating greater "waste to resource exchange" by sharing data. They created a framework for waste value chain stakeholders to identify technologies [24]. Mboli et al. proposed an IoT based decision support system for tracking, monitoring and analyzing products in real time that gives information about the forthcoming returned products [25].

Limba et al. analyzed big data implementation in municipal waste management. They ask, how digitalization will impact waste management and is it possible to apply big data instantly to increase the efficiency of waste management [26].

3 Methodology

This paper presents a qualitative case study, that describes Industrial Symbiosis relationship with one by-product user and three by-product producers. By-products in this case are biobased materials.

Empirical data were collected by thematic interviews on January 2021 that aimed to achieve understanding of the information sharing aspect in ongoing Industrial Symbiosis. Table 1 shows a description of the case companies.

Table 1. Description of the case companies.

Company	By-product user	By-product producer	Industry	By-product volume per year /kg
A	x		Biomaterial recycling and processing	
B		x	Food industry	1 500 000
C		x	Food industry	250 000
D		x	Forest industry	2 500 000

Within this case, information sharing is most vital between company A and B. Thus, this is the main case described in the Results chapter.

4 Results

"It is challenging, when you use by-products from other industrial actor – you just cannot order exact amount of material. No one produces by-products purposefully; it is a waste from production and naturally everybody aims to minimize the amount of waste. In addition, the changes in production volume will change the amount of by-product."

Company A

4.1 How Information Flows in Industrial Symbiosis and What Are the Gaps or Discontinuities?

What information relates to the by-product between Industrial Symbiosis partners and how it is shared? The by-product producer (company B) has a production forecasts for the full year, but its accuracy is poor. The amount of by-product generated during the month can be predicted relatively accurately, it is a certain percentage of the raw material used in the production. This information is sent weekly to the by-product user (company A) as an Excel file. Using this information, the user of by-product (company A) plans the logistics in order to pick-up material as well as the production.

The challenge for interaction is the fact that the forecast in by-product producer (company B) can change after it has been sent to the by-product user (company A); volume of the by-product might even be doubled and the by-product user (company A) is not always informed about changes. For this reason, the by-product user (company A) must keep active contact with the staff of the by-product producer (company B), to avoid the by-product containers to fill up. It is clear, that the by-product user (company A) feels that the development of interaction is important.

There is not this kind of information sharing or even needs to share information between other cases (company A-C and A-D). This is because of the volume of the by-product remains stable from week to week.

4.2 What is the Value Potential of Missing Information and What Are the Barriers to Share or Obtain It?

The by-product user (company A) plans its production and logistics in two-week periods, so the volume of the next two weeks should be known as accurately as possible. It is most critical fact, that the producer of the by-product (company B) must always have capacity left for the by-product and not have to interrupt the production. The by-product producer needs to know the exceptions in advance, as they produce large volume of by-product every day.

It would be best for the user of the by-product (company A) if they had a view to the by-product producer's system to see the current estimation of the production volume and the volume of by-product being generated. A two-week view would be enough, and

it should be updated on a weekly basis. In addition to plan the production and logistics, the user of the by-product (company A) needs information in order to trade the right volumes and on the other hand, ensure there is capacity available in stock. The producer of the by-product (company B) is not sure what information they would be willing to share.

There is no value potential enabled by information sharing in other cases (company A-C and A-D). This is because of the volume of the by-product remains stable from week to week, so information sharing would not provide any monetary value for these companies.

4.3 How Companies See the Role of Digitalization in the Development of Industrial Symbiosis and Are They Willing to Take Advantage of It?

The user of the by-product (company A) does not yet recognize how to exploit digitality to create monetary value. If they had access to the by-product producers' system, they would get up-to-date information. But the user of the by-product feels that the added value compared to Excel file is so small, that it is not worth to develop. The user also doesn't see the significance of being able to track the filling of the by-product container in real time – this information is communicated with the by-product producers' staff.

The by-product producer (company B) sees digitalization as useful for allowing automatic and predictable operations for both partners. The challenge is the fact that the production volumes for the next week can change in a couple of hours: if a promotion is sold today, next week's production could be doubled. Often such rapid changes are forgotten to inform the by-product user, which leads to the filling of the containers. To overcome this challenge, integration between partners' systems could be the solution.

The question of what information the by-product producer (company B) is willing to share, depends on the partner - there is no need to keep secrets, if there is a long-term partnership. The producer of the by-product (company B) says, that long-term partnerships can be created only by doing together successfully, jointly developing, sharing information and helping each other.

On the other hand, the producers of the by-product (company B and C) states that this is just a by-product for them, and they are not willing to invest in. However, the by-product producers (company B and C) thinks, that by developing the co-operation with the by-product user, it is possible to obtain a higher return from the by-product.

5 Discussion

The needs and the challenges for the information sharing in Industrial Symbiosis seems to depend on the type, volume and variation of the by-product. In some cases, information sharing is vital for the Industrial Symbiosis (between companies A-B), while other cases go steady without changes in volumes of the by-product (between companies A-C and A-D).

The development of information sharing is possible in the point of view of by-product producers (company B and C), but they are not willing to invest for the by-product related development unless it brings benefits for them by higher returns. However, there are other

potential by-product users in the market, so the by-product producers have the power to choose their partners.

Digitalization are expected to provide opportunities to develop Industrial Symbiosis and Circular Economy, by connecting waste producers and users and by sharing data [24, 25]. Within these cases, companies do not see that technology would provide added value enough to be worth to invest in, not even the by-product user (company A).

Interview results were in line with the theory of the drivers and barriers for Industrial Symbiosis: lack of trust and unwillingness to share data [9]; joint problem solving and shared vision [11]; logistics, volumes and market demand [12]; financial issues [11] and economic viability [14]. Logistics and market demand are the reason for information sharing, but the challenge is willingness to share information and lack of trust. Shared vision and joint problems solving was mentioned as important element for successful collaboration. Lack of monetary value was mentioned as a barrier to develop information sharing.

This paper presented a one case, biobased Industrial Symbiosis, with one by-product user and three by-product producers. This research will be continued by another case that is based on different materials.

References

1. Bakajic, M., Parvi, A.: Barriers to closing waste loops in the European union - implications for circular economy platforms in waste management (2018). http://urn.fi/URN:NBN:fi:aalto-201901181305
2. Tura, N., Hanski, J., Ahola, T., Ståhle, M., Piiparinen, S., Valkokari, P.: Unlocking circular business: a framework of barriers and drivers. J. Clean. Prod. **212**, 90–98 (2019). https://doi.org/10.1016/J.JCLEPRO.2018.11.202
3. Antikainen, M., Uusitalo, T., Kivikytö-Reponen, P.: Digitalisation as an enabler of circular economy. Procedia CIRP. **73**, 45–49 (2018). https://doi.org/10.1016/J.PROCIR.2018.04.027
4. Maqbool, A., Alva, F., Van Eetvelde, G.: An assessment of European information technology tools to support industrial symbiosis. Sustainability **11**(1), 131 (2018). https://doi.org/10.3390/su11010131
5. Grant, G.B., Seager, T.P., Massard, G., Nies, L.: Information and communication technology for industrial symbiosis. J. Ind. Ecol. **14**, 740–753 (2010). https://doi.org/10.1111/j.1530-9290.2010.00273.x
6. Benedict, M., Kosmol, L., Esswein, W.: Designing industrial symbiosis platforms – from platform ecosystems to industrial ecosystems. In: PACIS 2018 Proceedings, p. 306 (2018)
7. Luetje, A., Willenbacher, M., Möller, A., Wohlgemuth, V.: Enabling the Identification of Industrial Symbiosis through ICT. In: Proceedings of the 52nd Hawaii International Conference on System Sciences. Hawaii International Conference on System Sciences (2019). https://doi.org/10.24251/hicss.2019.087.
8. Ranta, V., Aarikka-Stenroos, L., Ritala, P., Mäkinen, S.J.: Exploring institutional drivers and barriers of the circular economy: a cross-regional comparison of China, the US, and Europe. Resour. Conserv. Recycl. **135**, 70–82 (2018). https://doi.org/10.1016/j.resconrec.2017.08.017
9. Neves, A., Godina, R., Azevedo, S.G., Pimentel, C., Matias, J.C.O.: The potential of industrial symbiosis: case analysis and main drivers and barriers to its implementation. Sustainability **11**, 1–68 (2019). https://doi.org/10.3390/su11247095
10. Fraccascia, L., Magno, M., Albino, V.: Business models for industrial symbiosis: a guide for firms. Procedia Environ. Sci. Eng. Manag. **3**, 83–93 (2016)

11. Päivärinne, S., Hjelm, O., Gustafsson, S.: Excess heat supply collaborations within the district heating sector: drivers and barriers. J. Renew. Sustain. Energy **7**(3), 033117 (2015). https://doi.org/10.1063/1.4921759
12. Cramer, J.: Key drivers for high-grade recycling under constrained conditions. Recycling **3**, 1–15 (2018). https://doi.org/10.3390/recycling3020016
13. de Jesus, A., Mendonça, S.: Lost in transition? Drivers and barriers in the eco-innovation road to the circular economy. Ecol. Econ. **145**, 75–89 (2018). https://doi.org/10.1016/j.ecolecon.2017.08.001
14. Dieckmann, E., Sheldrick, L., Tennant, M., Myers, R., Cheeseman, C.: Analysis of barriers to transitioning from a linear to a circular economy for end of life materials: a case study for waste feathers. Sustainability **12**(5), 1725 (2020). https://doi.org/10.3390/su12051725
15. Ghali, M.R., Frayret, J.M.: Social semantic web framework for industrial synergies initiation. J. Ind. Ecol. **23**, 726–738 (2019). https://doi.org/10.1111/jiec.12814
16. Yazdanpanah, V., Yazan, D.M., Zijm, W.H.M.: FISOF: a formal industrial symbiosis opportunity filtering method. Eng. Appl. Artif. Intell. **81**, 247–259 (2019). https://doi.org/10.1016/j.engappai.2019.01.005
17. Yeo, Z., Masi, D., Low, J.S.C., Ng, Y.T., Tan, P.S., Barnes, S.: Tools for promoting industrial symbiosis: a systematic review. J. Ind. Ecol. **23**, 1087–1108 (2019). https://doi.org/10.1111/jiec.12846
18. Wen, Z., Hu, Y., Lee, J.C.K., Luo, E., Li, H., Ke, S.: Approaches and policies for promoting industrial park recycling transformation (IPRT) in China: practices and lessons. J. Clean. Prod. **172**, 1370–1380 (2018). https://doi.org/10.1016/j.jclepro.2017.10.202
19. Fraccascia, L., Yazan, D.M.: The role of online information-sharing platforms on the performance of industrial symbiosis networks. Resour. Conserv. Recycl. **136**, 473–485 (2018). https://doi.org/10.1016/J.RESCONREC.2018.03.009
20. Fraccascia, L., Yazdanpanah, V., Van Capelleveen, G., Yazan, D.M.: A framework for industrial symbiosis systems for agent-based simulation. In: Proceedings - 21st IEEE Conference on Business Informatics, CBI 2019, vol. 1, pp. 419–428 (2019). https://doi.org/10.1109/CBI.2019.00055
21. Kosmol, L.: Sharing is caring-Information and knowledge in industrial symbiosis: a systematic review. In: Proceedings - 21st IEEE Conference on Business Informatics, CBI 2019, vol. 1, pp. 21–30 (2019). https://doi.org/10.1109/CBI.2019.00010
22. Cervo, H., Ferrasse, J.-H., Descales, B., Van Eetvelde, G.: Blueprint: a methodology facilitating data exchanges to enhance the detection of industrial symbiosis opportunities – application to a refinery. Chem. Eng. Sci. **211**, 115254 (2020). https://doi.org/10.1016/j.ces.2019.115254
23. Kurilova-Palisaitiene, J., Lindkvist, L., Sundin, E.: Towards facilitating circular product lifecycle information flow via remanufacturing. Procedia CIRP **29**, 780–785 (2015). https://doi.org/10.1016/j.procir.2015.02.162
24. Kerdlap, P., Low, J., Ramakrishna, S.: Zero waste manufacturing: a framework and review of technology, research, and implementation barriers for enabling a circular economy transition in Singapore. Resour. Conserv. Recycl. **151**, 104438 (2019). https://doi.org/10.1016/j.resconrec.2019.104438
25. Mboli, J.S., Thakker, D.K., Mishra, J.L.: An Internet of Things-enabled decision support system for circular economy business model. Softw. - Pract. Exp. 1–16 (2020). https://doi.org/10.1002/spe.2825
26. Limba, T., Novikovas, A., Stankevičius, A., Andrulevičius, A., Tvaronavičienė, M.: Big data manifestation in municipal waste management and cryptocurrency sectors: positive and negative implementation factors. Sustainability **12**(7), 2862 (2020). https://doi.org/10.3390/su12072862