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SHORT ARTICLE



Initiating resource partnerships for industrial symbiosis

Anne P. M. Velenturf

ABSTRACT

Industrial symbiosis is a strategy to limit carbon emissions whilst promoting resource efficiency and business development. This study interprets industrial symbiosis as waste-to-resource innovation. Understanding how these innovations are actually realized, and hence how they can be promoted by public and private partners, is still limited. Particularly, initiating resource partnerships for waste-to-resource innovations in the absence of a government-funded facilitator, such as previously the National Industrial Symbiosis Programme (NISP) in the UK, has remained underexplored. This paper explores how companies identify potential resource partners in terms of network and geographical distances. Based on case studies of waste-to-resource innovation in the Humber region of the UK, the paper concludes that (1) companies can identify resource partners among/through their direct contacts that are involved in resource production/management themselves; and (2) that about 73% of these connections are located within a 75 miles' radius. Furthermore, various new 'facilitators' were identified, demonstrating the need for a refined government approach to facilitate industrial symbiosis as part of the wider transition towards the circular economy.

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KEYWORDS

self-organized industrial symbiosis; networks; geographical proximity; waste-to-resource innovation; circular bio-economy; business strategies

INDUSTRIAL SYMBIOSIS RESEARCH ON INITIATING RESOURCE PARTNERSHIPS

Industrial symbiosis is a recognized strategy to limit carbon emissions whilst promoting resource efficiency and business development (Laybourn & Morrissey, 2009). Industrial symbiosis can be interpreted as the innovative process in which the waste from one company is used as a resource by another, i.e., waste-to-resource innovation (Frosch & Gallopoulos, 1989; Jensen, Basson, Hellawell, Bailey, & Leach, 2011). In addition to these resource partners, the realization of industrial symbiosis can also involve other actors such as governments and technology providers. Actors involved might exchange information, materials and/or energy (Chertow, 2000; Korhonen, von Malmborg, Strachan, & Ehrenfeld, 2004). Hence, it could be said that industrial symbiosis involves network development. Although there has been some research on industrial

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symbiosis networks in the industrial ecology community (e.g., Ashton, 2008; Doménech & Davies, 2009; Paquin & Howard-Grenville, 2012), open qualitative empirical explorations are rare (Romano, Vincenzo, & Raggi, 2012; Velenturf & Jensen, 2016). Consequently, understanding of how industrial symbiosis actually develops, and hence how it can be promoted by public and private partners, is still limited.

Three broad models for the development of industrial symbiosis, ranging from government-planned to facilitated and self-organized approaches, have been distinguished (Paquin & Howard-Grenville, 2012). When the government plans or facilitates the development of industrial symbiosis, resource partners are identified for companies by the government or through publicly funded programmes such as previously by the National Industrial Symbiosis Programme (NISP) in the UK. The government or facilitator acts as network broker, which can be understood as a coordinator that initiates and manages connections between resource partners (Paquin & Howard-Grenville, 2012; Provan & Milward, 2001). Conversely, in the case of self-organized industrial symbiosis (which is the prevailing model in the UK since public funding for NISP stopped in 2012), companies need to initiate resource partnerships themselves without government support. Despite various studies on self-organized industrial symbiosis, the initiation process for resource partnerships has remained largely unexplored.

Rather than exploring the actual process through which industrial symbiosis is realized, research has tended to list barriers and success factors (Madsen, Boisen, Nielsen, & Tackmann, 2015; Velenturf & Jensen, 2016). The importance of a limited number of factors, such as social and geographical proximity between resource partners, has been emphasized (e.g., Chertow, 2000), though rarely empirically questioned. In the case of geographical proximity, research on waste resource flows suggests that distances between resource partners can vary considerably (Jensen et al., 2011; Lyons, 2007). Jensen et al. (2011) observed that waste resource movements facilitated by NISP varied from 0.1 to 269 miles, while 90% of all movements between resource partners were within 75 miles. Lyons (2007) recorded waste resource movements varying from local to (inter) national scale. Converse to these studies on *metabolic* networks comprised of material and energy flows, geographical distances in *social* networks (including information flows) associated with industrial symbiosis have not yet been explored (Romano et al., 2012; Velenturf & Jensen, 2016).

In sum, there are significant knowledge gaps pertaining to the process through which self-organized industrial symbiosis develops, the ways in which resource partnerships are initiated and the role of geographical distances between the actors involved. Consequently, it has been challenging to translate research outcomes into practical recommendations for the promotion of industrial symbiosis. This article aims to add to the practical understanding of realizing industrial symbiosis and to complement research on the development of resource partnerships after they were initiated (Velenturf, 2016). Its objective is to explore how companies identified potential resource partners in the first instance by answering the question: Where did companies find potential resource partners in terms of network and geographical distances?

RESEARCHING INDUSTRIAL SYMBIOSIS IN THE HUMBER REGION OF THE UK

Research was carried out in the UK's Humber region (Figure 1). Located in the north-east of England, the Humber region hosts one of the busiest port complexes in the UK and has a predominantly agricultural hinterland. It is one of England's most diverse and mature industrial systems (Jensen, 2016). Five qualitative exploratory case studies looked at companies adopting industrial symbiosis in the form of a waste-to-resource innovation (Frosch & Gallopoulos, 1989):

- 'Fuel producer' searching for customers for waste oil.
- Energy-intensive company searching for suppliers of anaerobic digestion plant feedstock.

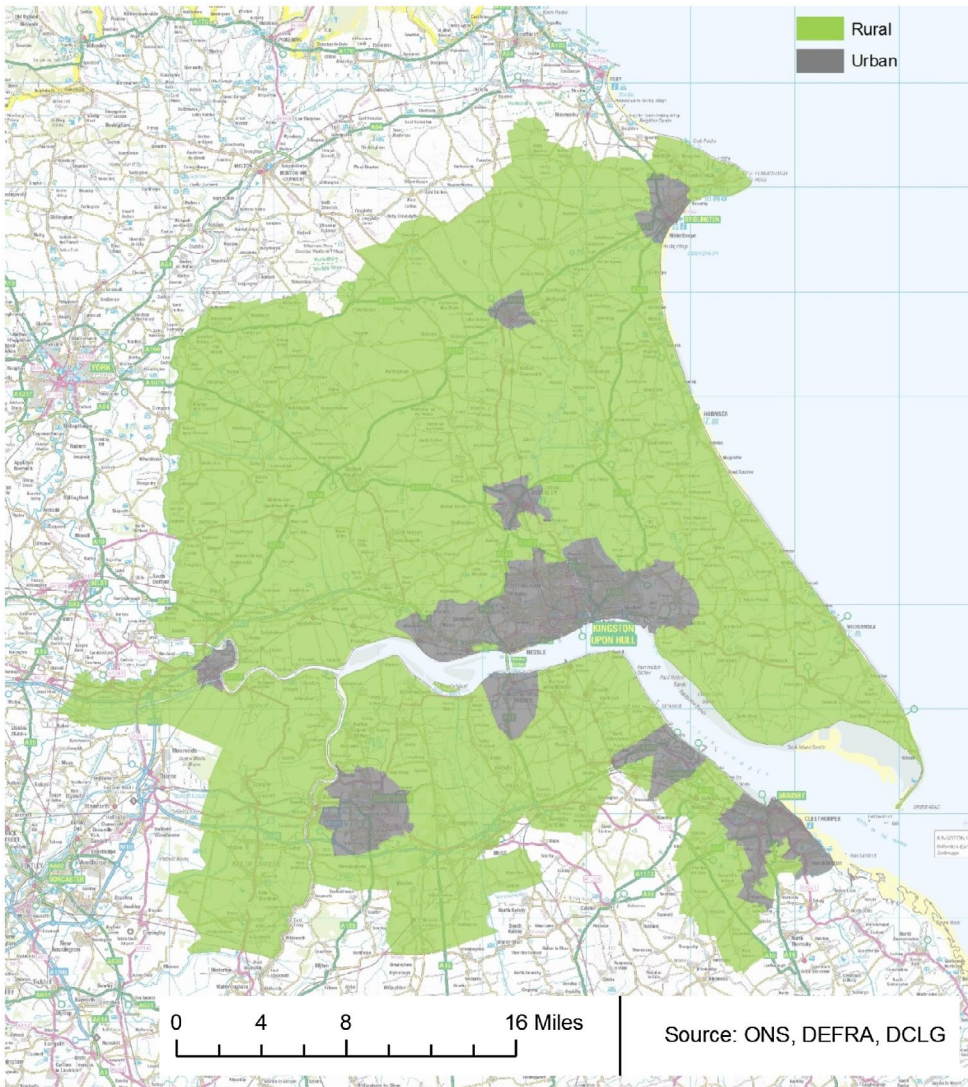


Figure 1. The Humber region is an industrially diverse yet mostly rural area located on the coast of the north-east of England with ports facing Europe. Courtesy: Crown Copyright and database rights 2014 Ordnance Survey Licence No. 100022861.

- Energy-intensive company searching for suppliers of refuse-derived fuel.
- Steam-producer searching for waste-wood suppliers and customers for steam.
- Specialist recycler and fuel producer growing their partnership for biofuel manufacturing.

As part of a larger research project (see also Velenturf, 2016), the case studies were designed to explore how and why these waste-to-resource innovations developed. Key individuals closely involved with the innovations were interviewed. The semi-structured interviews focused on understanding the consecutive actions taken by the interviewee, the company they represented and their resource partners, leading to the realization of the innovative resource flows. Additionally, information was collected about contextual dynamics impacting on the developing partnerships. Interviews were transcribed before analysis and complemented with documents such as permit

applications and news articles to gain a thorough understanding of the development of relations with resource partners and others involved in the innovation processes.

Data were processed with conceptual and open coding. Codes included (but were not limited to) network actors and relations, absolute and relative proximity (Boschma, 2005), self-organized and facilitated relations (Paquin & Howard-Grenville, 2012), and order of events during the innovation process. Data were further interpreted in several steps. The role of each code was analysed in isolation and in relation to other codes. Then a holistic understanding of the innovation processes was developed in case study reports. The interpretation was completed with a cross-case comparison.

ANALYSING PATTERNS IN INITIATING RESOURCE PARTNERSHIPS

Network development

The network development for each waste-to-resource innovation was analysed in detail (Figures 2(a–e)). The case study participants generally identified potential resource partners through a shared contact that functioned as a ‘network broker’:

- In case 1, ‘Waste oil’, the participant identified a suitable resource broker, a company specializing in facilitating by-product exchanges that was already contracted by another production site belonging to the same parent company. In turn, the resource broker identified a company that could use the waste oil (Figure 2(a)).
- In case 3, ‘Refuse-derived fuel’ (RDF), the case study participant identified a new technology, and a company that had already adopted it, from a sector journal. After contacting the energy-intensive company that had adopted the technology using RDF, that company facilitated the contact between their RDF supplier and the case study participant (Figure 2(c)).
- Case 4, ‘Waste-wood fuel’, involved a complex sequence of brokered interactions between parent and daughter companies. The studied innovation consists of two symbioses, one of which stems from a facilitated connection between two of the parent companies that were using the same storage facility. The symbiosis between the steam and wood-fuel producer was a continuation of a long-term collaboration between the two business groups (Figure 2(d)).

In two cases the resource partners already knew each other:

- While the resource partners in case 2, ‘Agricultural feedstock’, already knew each other, the studied resource partnership for the anaerobic digester was initially suggested by a shared contact (Figure 2(b)).
- In case 5, ‘Waste oils and fats’, the connection between the two resource partners was originally facilitated by NISP, i.e., a classic example of facilitated industrial symbiosis. Over time, the partnership then evolved into a closer collaboration involving the treatment of increasing quantities of various waste oils and fats, which could be interpreted as a self-organized continuation of the facilitated symbiosis (Figure 2(e)).

The analysis indicates that the resource partners either already had direct contact or were connected by a shared contact that functioned as a network broker. The results revealed more variation in which actors can function as network brokers than is currently visible in the industrial symbiosis literature. These included members of the company group, production sites within the same company, specialized by-product management companies (showing much resemblance to

government-funded facilitators such as NISP), landlords/site-owners, and companies publishing in industry journals. Except for the journal, all network brokers were themselves involved in producing and/or managing resource flows.

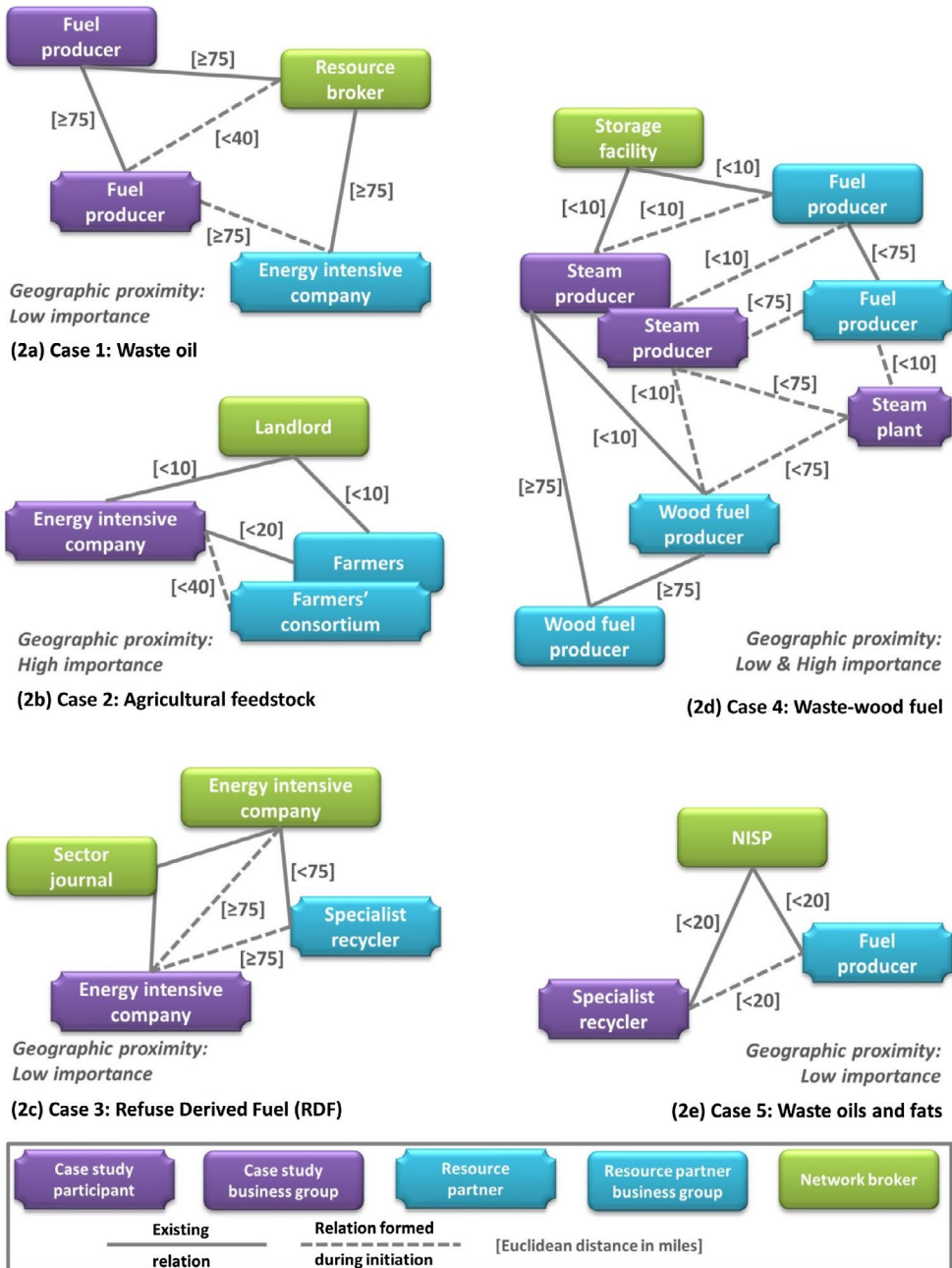


Figure 2(a–e). Resource partnerships were formed between case study participants’ plants within the Humber region, and in some cases their business groups, and their waste resource suppliers/clients. In most cases the relationship was brokered by a shared contact, i.e., a ‘network broker’. Distances between resource partners as well as brokers varied from fewer than 10 miles to over 75 miles for (inter)national connections.

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GEOGRAPHICAL PROXIMITY

Locations of resource partners and network brokers span across the Humber, the UK and Europe, ranging in distance from less than 1 mile to over 600 miles (Figure 2). However, most connections were between actors within 75 miles of each other.

Geographical proximity was considered important in all relations in case 2, 'Agricultural feedstock', and in some relations in case 4, 'Waste-wood fuel'. In these relations the social contacts were inherently tied to a shared location and were considered crucial in the forming of the connections. In the other relations, geographical proximity was considered less important during the initiation. In case 1, 'Waste oils', and case 3, 'Refuse-derived fuel', the long overseas connections were a necessity due to an unfavourable regulatory context in the UK in case 1 and the introduction of a new technology and resource to the British market in case 3. In case 5, 'Waste oils and fats', the distances were relatively short, but generally this was not considered important and the participants perceived that the resource partners could have been over 150 miles apart. However, the continued self-organized growth of the partnership was fostered by shared management of the two sites, which was based on close geographical proximity.

Finally, the geographical distances found during the initiation should not be considered typical for the studied symbioses. All participants considered resource partners at shorter and longer distances as their partnerships developed for reasons related to economic value and/or resource security (Velenturf, 2016).

REFLECTING ON INDUSTRIAL SYMBIOSIS LITERATURE

The results revealed that potential resource partners were either already direct contacts or had a shared contact that could introduce them or suggest symbiotic collaboration. This organic growth of the industrial symbiosis network seems to be in line with earlier suggestions that one symbiotic relation leads to further resource innovations (e.g., by Jensen, Basson, Hellowell, & Leach, 2012; Short, Bocken, Barlow, & Chertow, 2014).

The role of shared contacts functioning as network brokers or coordinators adds nuance to understanding the difference between facilitated and self-organized industrial symbiosis. While 'facilitated' tends to be used to refer to coordination by governments/publicly funded programmes such as NISP (Paquin & Howard-Grenville, 2012), the case studies were facilitated, however, directly by the private sector themselves. The results suggest that the distinction between spontaneous and facilitated industrial symbiosis is not as sharp as implied before, since a broader range of actors acted as network brokers or facilitators than had previously been identified. Case 5, 'Waste oils and fats', adds further nuance by showing how facilitated synergies can lead to self-organized industrial symbiosis.

Turning to geographical proximity, the variation in distances was similar to earlier observations of metabolic networks (e.g., Jensen et al., 2011; Lyons, 2007). For social connections, geographical distances were only considered important in a minority of relations, which contradicts earlier arguments on proximity (see Velenturf & Jensen, 2016, for a detailed literature review). Adding to Jensen et al.'s (2011) analysis of metabolic flows in the case of *facilitated* industrial symbioses, the majority of social connections analysed in this study of *self-organized* industrial symbioses were within a 75-mile radius. There were, however, a relatively large number of social connections and associated metabolic flows at distances over 75 miles (about 27% compared with 10% observed by Jensen et al.).

Perhaps longer distances between resource partners in self-organized symbioses could be anticipated when compared with facilitated industrial symbiosis. First, as argued above, the composition of existing networks clearly influences the emergence of new resource partnerships. Hence, if a

company has a geographically wide-ranging network, then the chances are that potential resource partners are also situated further afield. Second, while companies may have good knowledge of sector(s) with which they already engage, they are unlikely to have in-depth knowledge of sectors that are new to them while, for example, regional NISP practitioners could draw upon a database of thousands of companies and synergies. However, considerable further research is necessary to explore these ideas further.

Finally, the transferability of the findings to other regions needs further research. Industrial diversity has been linked to the abundance of industrial symbioses (Jensen, 2016). Given the high industrial diversity of the Humber region, companies in less diverse areas may have to search a wider area to identify resource partners.

IMPLICATIONS FOR PRACTICE, POLICY AND ACADEMIA

This article presented a first exploration of the ways in which companies identified resource partners in terms of network and geographical proximity. The conclusions can be summarized in three points:

- The results showed that companies can identify resource partners either among or through their direct contacts that are involved in the production or management of resources and that are predominantly located within a 75-miles radius.
- The results revealed how companies initiated resource partnerships supported by a variety of network brokers. Further research is necessary to understand better the range of actors functioning as network brokers for industrial symbiosis, their commercial interests in resource synergies, the strategic implications for broader economic transitions that private sector brokers could realize compared with publicly funded facilitators, and the role that a government-funded facilitator should play in promoting industrial symbiosis. Such insights need to be included in the development of government strategy for industrial symbiosis, as part of promoting the wider transition towards the circular economy.
- While this article presented the practical implications for the promotion of industrial symbiosis and opened new perspectives on network brokerage, it also identified various research gaps. In addition to the policy-relevant research on network brokerage for industrial symbiosis, further research needs to be carried out on the effects of existing networks, industrial diversity, and companies' and facilitators' sectoral knowledge on geographical proximity between companies during the initiation of resource partnerships.

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