Challenges to the Uptake of Industrial Symbiosis for Improved Waste Management: Experiences from the Western Cape Industrial Symbiosis Programme

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ABSTRACT
Industrial symbiosis (IS) is typically characterised by one company's waste or by-product being used as a resource by another company. IS can be a simple and appealing approach to resource efficiency and landfill diversion. However, IS can be hindered by various institutional and technical barriers. Businesses trying to benefit from IS often find themselves grappling with legislative, capacity, logistical and various other constraints. Since its inception in 2013, the Western Cape Industrial Symbiosis Programme (WISP) has identified more than 1000 potential synergies between businesses within the Western Cape. The paper highlights barriers to the realisation of these synergies based on the WISP experience. The barriers identified are not unique to the Western Cape or South Africa. Globally, businesses trying to implement IS face similar challenges. A good business case is key to the successful implementation of IS. Government and other industrial bodies also have an important role to play to create an enabling environment for IS.

1. INTRODUCTION

1.1 General Overview

Diminishing natural resources and threats of climate change are leading industries to rethink the way they conduct business. Focus is shifting towards resource efficiency, and finding alternative sustainable substitutes for the finite resources that are either becoming limited in their availability or have a large negative environmental impact. There is a drive to shift from the traditional linear methods of production to more circular approaches where materials and energy are re-integrated into processes (either the same or a totally unrelated process); something that can be achieved through a systems approach where industries and processes are not looked at in isolation.

Industry can learn from nature and specifically where entities have a symbiotic relationship. Among other examples of symbiosis, waste from one entity is food for another leading ultimately to a sustainable circulation of nutrients through ecosystems leading to a *natural circular economy*. The same concept applied to industry would enable the return of waste materials into the economy. The Western Cape Industrial Symbiosis (WISP) was borne out of the idea that there are opportunities for secondary material utilisation by getting companies to share their under-utilised material with other companies that can use them (wastes, by-products and other excess resources such as energy, capacity, land). With South African landfills running out of space, IS can help *divert large volumes of waste from going to landfill*, with the added benefits to businesses of *saving on disposal costs* and the *potential to generate revenue* (with or without value add to waste streams) which can be sold to other businesses that can use them. The resultant reduced use of virgin material thereby *slowing down the depletion of our finite resources*. There are opportunities for job creation through expansion of capacity and creation of new businesses altogether. Despite their potential benefits and historical examples, the number of comprehensive, operational IS networks is limited. This is mostly due to the fact that the development and operation of such networks are dependent on the presence (or the lack) of the right mix of various determining factors rooted in *technical*, *informational*, *political*, *economic*, and *organisational* spheres (Mirata & Pearce, 2004). Although theoretically simple, the application might actually be a complex process due to these factors. Hence the success of any IS programme or the realisation of a particular synergy is not only dependent on the willingness of the parties involved to exchange resources.

1.2 Objective

This paper analyses barriers to IS in relation to a number of case study synergies and proposes potential solutions to overcome them, enabling landfill diversion, resource efficiency and wider economic, environmental and social benefits of IS to be realised in South Africa.

The findings illustrated in this paper are based on WISP experience over the three-year period that WISP has been operational.

2. BARRIERS: A GLOBAL PERSPECTIVE

There is substantial literature that focusses on barriers and enablers to Industrial Symbiosis (IS) globally. Without delving too deep into the details, the major constraints mentioned in literature that businesses encounter when trying to implement IS activities will be highlighted. The barriers are most often broken down into sub-categories like *legislative, technical, economical, logistical, capacity*. It is of note the barriers are not mutually exclusive. For example, a barrier can be categorised as *technical and economic/financial* at the same time. Two models of IS are usually applied. One is Eco Industrial Parks (EIPs) where businesses that are co-located apply IS and form resource exchange networks within an area. These can develop organically or can be planned. The other model is where businesses based on feasibility and interests will exchange resource and thereby form symbiotic networks that are not restricted by geographical location. Both models can either be facilitated or self-organised. WISP is a facilitated model where there are practitioners identifying IS opportunities, facilitating the exchange of resources and thereby establishing IS networks between companies as opposed to an organic model where IS happens without any external intervention

2.1 Denmark: Self Organised IS

An IS case study, that is well publicised, is the Kalundborg industrial area in Denmark with most authors refering to it when discussing IS activities. Kalundborg has almost become synonymous with IS. According to Kurup et al. (2005), the power station manager in Kalundborg coined the term “Industrial Symbiosis”. The linkage started with the exchange of excess steam from Asneas power plant and surplus gases from Statoil refinery in the 1970s, and evolved into a network of synergistic linkages between the power plant, the refinery, a plasterboard manufacturer, a pharmaceutical plant, a sulphuric acid manufacturer, a cement company, local farmers, fish farms and the local community (Mirata & Pearce, 2004). Kurup et al. (2005) also stated that the resource exchanges that took place in Kalundborg only materialised if they were found to be economically beneficial from the outset - in other words economics (i.e. the business case) dictated the practical implementation of IS activities in the area. The exchanges in the region were negotiated over a period of more than three decades (Kurup et al., 2005). This is a critical point to note as it can serve to remind us that sometimes it takes time to establish (structural) changes in systems. Kalundborg transitioned into an eco-industrial park organically without any external interventions.

2.2 The Netherlands: Facilitated Co-Located IS

To emphasise the importance of policy and regulation, Costa et al. (2008) suggested that if Danish regulation were to be similar to U.S. regulation, IS development at Kalundborg would have been a very difficult if not impossible task (Costa, Massard, & Agarwal, 2010). The key take away being that policies can serve to either hamper or facilitate IS and what applies in one area might not necessarily apply in another. There has not been any longitudinal surveys to compare whether a facilitated approach is better than an organic approach. Rotterdam in the Netherlands was a facilitated co-located case, where the government facilitated projects to strengthen economic and environmental performance in industry by partially funding IS projects. Baas (2008), as cited in Costa et al. (2010), observed that although the regulator engaged with the companies to adjust rules, the policy environment still perceived synergies as handling waste rather than reusing resources. Another challenge related to the requirement of technological treatment standards for companies who wanted to use wastes as raw materials. These technological standards aimed to maximize efficiency with the least environmental impact and companies needed to adhere to them in order to receive the necessary permits. However, the potential recycling role of manufacturing technologies already in place was seldom evaluated. That meant that, in order to utilise a waste, companies needed to invest in additional equipment, which could reduce the economic benefit of using a raw material substitute.

2.3 UK and Wales: Facilitated Networks

In the UK, efforts to catalyse the development of IS networks started in 2000 when the Business Council for Sustainable Development – United Kingdom assumed the role of facilitating an IS network development among the economic activities located in the Humber Estuary. The Humber region Industrial Symbiosis Programme (HISP from hereon) sparked interest from other UK regions, which lead to the development of the UK wide National IS programme (NISP) (Mirata & Pearce, 2004). A summary of factors that were regarded as having major influence on the development and functioning of IS networks and an elaboration on the roles coordination bodies could play in light of these determinant factors have been highlighted by Mirata & Pearce (2004). Two of the main roles coordination bodies could play are related, but not limited, to providing assistance with informational and organizational issues Facilitation bodies are considered essential to catalyse the development and functioning of IS (Mirata & Pearce, 2004). One organisation that was instrumental in the IS space is the UK based International Synergies Limited (ISL) which designed and managed the UK National Symbiosis Programme (NISP). In an interview, Laybourn (2008) — ISL and NISP founder member — stated that mind-sets were the primary barrier that impeded IS. He advocated for a systems thinking as a way of shifting mind-sets. Something he believed could be achieved through training. "*People are not trained to work outside their sectors and therefore need someone to help them open their eyes and see everything as a resource and not as waste. Barriers or enablers such as policy and regulation, organisational priorities and technical challenges, are key obstacles, but the lack of systems thinking and cross sector working remained key" (*Laybourn, 2015).

Chamberlin et al. (2013) wrote on circular economy and IS from a Welsh perspective. The general sense was that the concept of circular economy and IS was still unfamiliar and often misunderstood. Businesses often reverted to the traditional view of waste as a burden as they interpreted circular economy as just another recycling, 'green' or sustainability initiative. Traditional ways of doing things versus new ways — a point Sinnot (2005) brings to fore when he stated that, when innovation is necessary, previous experience, through prejudice can sometimes serve to inhibit the generation and acceptance of new ideas. There was a failure to recognise the opportunities for valorisation as laid out by the circular economy due to the conflation of reuse, repair and remanufacturing with recycling (or more accurately, downcycling). Fragmentation of objectives and targets at a government level meant that departments often struggled to collaborate on broader, cross-cutting agendas. Added to that long complex supply chains crossing many continents make it difficult for manufacturers to fully understand the materials being used in products and to design processes for materials recovery and reuse. This does not only cause confusion, but disincentivises effective valorisation of waste. Shifting volumes of products through a linear system without regard for reverse logistics or valorisation is at present a poor fit for thinking in systems through a circular economy (Chamberlin et al., 2013).

2.4 Australia – Principally Co-located IS

Cordal et.al (2014) gave a critical overview of the status of IS in Australia by examining the barriers and potential strategies to realise greater uptake and application of the concept. They conducted an analysis across three categories (heavy industrial areas, mixed industrial parks and waste exchange networks). The barriers investigated were regulation, information, community, economic, technical, cooperation and trust, and commitment to sustainable development. Some of the things they highlighted were: legislation should be prepared to encourage well-known but also potential waste reuse options to overcome limited incentives and guidance for the best environmental outcomes (Corder et al., 2014). In his review, Harris (2007) suggested that three 'success factors' necessary for IS projects to be realised were the ability to prove to businesses that there was a business case by looking at opportunities to reduce costs, new revenue generation, and/or secure access to vital resources that can be utilised by one or more businesses. At the minimum all government approvals should be in place, but preferably also endorsement from affected communities, key non-governmental organisations and/or an opportunity to create or improve skills, jobs and/or livelihoods. The last success factor he mentioned was proven technology i.e. ensure that process and equipment were available to make the resource synergy happen, such that the resources being transferred between the companies involved could be converted as and when required (Harris, 2007)

A survey carried out on South and West Australian SMMEs (Small Micro Medium Enterprises) found that despite the large aggregate waste quantities SMMEs produced, they still had difficulty engaging recycling collection. This was largely due to their individual recyclable loads (raw material sent to, and processed in, a waste recycling plant) being too small to make the provision of a service viable (Global Systems for Industrial Ecology and Recycling Of Metals In Australia, 2014). Another well publicised example of co-located IS is the Kwinana Industrial area which saw an increase in the number of core process industries in the 90s (from 13 to 21) leading to symbiotic exchanges increasing from 27 to 106 within the period. Corder et al. (2014) reviewed the status of IS in Gladstone (largest industrial area in Queensland, Australia and another classic example of co-located IS) and highlighted some insights into the non-technical barriers for higher uptake of the existing waste reuse opportunities. The authors recognised the need for more detailed environmental reporting for public interest. This would include regular summary reports for the whole area to address the lack of information sharing between different industries. Industries recognising their contribution to community capacities should be one of the most important outcomes of their activities in an area or at least allowing local communities greater determination concerning future industrial development in the region.

2.5 South Africa – Facilitated IS

In a South African context, the lack of legislative support further hampers the growth of IS, especially in situations where there is no clear guidance as to the responsibilities of the parties associated with the waste streams (Brent et al. 2008). In a paper focusing on advancing the concepts of industrial ecology in South Africa, Brent, et al. (2008) identified a number of barriers that needed to be overcome to facilitate the adoption of industrial ecology in South African institutions. Companies cited the following issues as constraints.

- Propriety/confidential information (trust issues).
- Negotiating balance of payments (under- or over-valuing of resources, possible price fishing).
- Reluctance on the part of a business/waste producer to be involved in inflexible contractual commitments that do not relate directly to their core activity. This may include guaranteeing a waste stream for a contractual period, supervising and operating a co-treatment facility, and in general the complexity of managing the wastes produced by other companies.

Brent et al. (2008) reason that ongoing regional case studies could lead to solutions that will overcome these barriers. They suggest that economic development officials and researchers should focus on promoting policies that will remove the obstacles to the recovery of industrial resources; as well as educating the public and private sectors as to the benefit of IS. Greater emphasis should be on the development of tools that would more effectively encourage and enable individual companies to manage waste streams effectively, while leaving them the necessary freedom to develop new and profitable uses for by-products should be developed (Brent et al., 2008)

2.6 General

Chertow (2007) mentions that problems rooted in the operational, financial, and behavioural issues raised by the need to work across organizations compounded by the usual problems of business development pose a barrier to the implementation of IS. Gerter & Ehrenfeld (1997) suggest that introduction of large disposal costs and subsidies can serve to improve IS uptake to the levels previously seen in Kalundborg as this will create favourable economics for recyclers (levelling the playing field possibly skewing it in their favour). Although it logically makes sense to implement IS, it still faces a number of barriers including the limited evaluation of the complete costs and benefits of IS to both the individual participants and at the project level (Kurup, Altham, & Berkel, 2005).

3. BARRIERS IN THE SOUTH AFRICAN CONTEXT: AWESTERN CAPE PERSPECTIVE

3.1 Definition of Barriers

Drawing on the review of international experience and building on the experience developed in delivering the Western Cape Industrial Symbiosis Programme (WISP), the range of barriers have been identified. Below, these are listed and defined.

3.1.1 Technical

Quality of Resources: Contaminated materials that fail to meet the required specification for use as either raw material or products. In most instances observed, upgrading the material to a higher quality specification cannot be done economically. In some cases, there is a lack of technology (non-existent, not advanced enough to do the job, or very expensive to install/build/operate) to do the concentration/recovery or processing of particular waste/by-product streams.

Resource Availability: Sometimes there are no viable amounts of a material to justify capital investment. The technologies and markets may be established, but if there is not enough raw material, then the business case collapses.

Consumer Confidence: This is an area where businesses like to tread carefully: there is a perceived notion that consumers are sceptical about products made from recycled/alternative materials. Whether this is true or false is debatable and dependent on a number of factors, but in the end, this ultimately discourages businesses from experimenting with alternative materials.

3.1.2 Legislative

Lack of Understanding: Herein defined as lack of understanding of regulation and policies. Often this is due to misinformation stemming from the wrong interpretation of regulations and policies.

Legislation not suited for South African environment or not adapted for new (green) technologies An example of this is wholesale classification of material e.g. classification of material as hazardous without taking into account the source of the material (e.g. foundry sand from ferrous foundries vs non-ferrous foundry sand - the former is non-hazardous whilst the latter is hazardous).

Over regulated environment: Businesses & entrepreneurs feel confined - there is limited space or incentive to be innovative as there are extensive regulations to navigate at every step.

3.1.3 Economic

Financial: There are cases when businesses are reluctant to pursue a synergy where they might have to make an investment. Businesses are not be willing to spend money if they do not have to and there is not a strong business case. This can be due to oversight or as Laybourn (2008) stated lacking systems thinking approach. Businesses use indicators like return on investment and payback to evaluate opportunities. If these numbers are not attractive, there is a higher probability that businesses will not pursue IS. Hence if there is no sensible business case to be made, it translates to no synergies taking place.

Economies of scale: A certain throughput and product output may be required to merit investment and provide the returns required by investors in (processing) technology.

Access to capital: Many businesses, especially SMMEs, do not have access to (affordable) capital which hampers enterprise development and investments in new technologies.

3.1.4 Logistics

Transport: It is still expensive to transport goods from one point to another. Transport costs can cancel out the benefits brought about by use of alternative materials as it becomes more uneconomical as the distance between two points increases. Added to that is the issue of finding legally compliant vehicles to transport certain materials.

3.1.5 Capacity

They are synergies (on the WISP database) that logically should have taken place, but for some unknown reason are still pending completion. This can be attributed this to capacity; the assumption being, either the companies do not have time to progress the synergies or they lack the human resource to see them through. Businesses also tend to focus on their core business and IS is often relegated to the bottom of the priority list.

3.2 Synergy Identification & Progression

Industrial Symbiosis starts with a resource matched to two or more organisations. One business has the underutilised resource and businesses that can potentially use the resource are or vice versa (i.e. a business needs the resource and ones that can supply it are identified). After this initial potential synergy identification process, the synergy is recorded on the WISP database as an idea. The synergy can progress through various stages (based on the methodology developed by ISL:

- Idea: Potential match is identified and recorded.
- Discussion: The facilitator puts the two businesses in contact and discussions will commence.
- Negotiation: Based on the discussions, businesses will start negotiating the dynamics of the exchange, such things as legal compliance, logistics and the finer details like whether there will be exchange of money are done at this stage.
- Implementation: Negotiation phase is over and businesses have agreed on the exchange. All the paper work is handled at this stage.
- Completion: The resource is exchanged between businesses and the exchange and its benefits reported to the programme.
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From the idea stage to the completion stage, they are barriers that businesses will encounter, some will come early on, and are identified at the idea stage and some barriers are experienced as the synergy is progressed. There is no correlation between the barriers and stage of progression. With that said, below is a graph of synergies that WISP has logged onto the database, but still have not been progressed to completion due to one or more of the barriers outlined above.

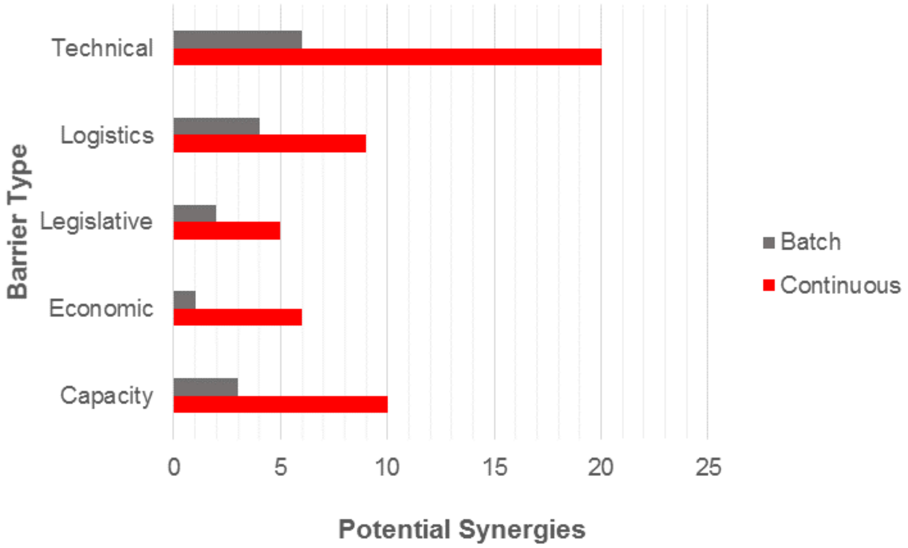

Figure 1: Number of synergies that have not been progressed to completion and the dominant barriers preventing completion

Of the 1000 plus potential synergies identified thus far, excluding the 50 that have been progressed to completion, 66 are held up between the idea stage and the completion stage (i.e. have not been progressed to completion). The synergies have been sub-divided into continuous and batch synergies. Continuous type of synergies are those that will be repeated in a certain period (i.e. weekly, monthly etc.), whilst batch type synergies are once-off. The barriers encountered along the progression path have been aggregated to give an overall picture (i.e. not mapped against stage of completion as well). Approximately 25% of the uncompleted synergies are batch type (i.e. the majority of incomplete synergies are continuous), which agrees well with the data for completed synergies where the bulk of the completed synergies are batch type.

3.3 WISP Experience

Below are some examples of the situations that WISP has encountered that give more detailed insight into the barriers typically encountered.

3.3.1 Case Study 1: Technical / Economic

A frequently encountered barrier to realising synergies in the Western Cape is economics, particularly where investment is required to enable the material to be used i.e. the return on investment / payback period is not considered acceptable and/or there are challenges to access finance. This hampers access to appropriate/value-add technology (Technical). These types of financial barriers have been most evident in the paper recycling companies as well as WISP's brewery, foundry, dry wall manufacturing and food & beverage members.

WISP has a number of companies producing large volume wastes. Some are a mix of by-product material and water. It is understood that there are no financially viable technologies available in the Western Cape to extract water from various waste streams to suitable materials for reprocessing. This is evident in brewery filter sand and paper pulp sludge from paper recyclers.

WISP also has two members, a glass recycler and a drywall manufacturer, who do not have financially viable technology to process specific waste streams that would allow them to increase recycling capacity. The glass recycler has rudimentary sheet glass processing technology. However, they are unable to process laminated sheet glass. Such technology is expensive and is not viable for the size of their operation. The drywall manufacturer produces large volumes of by-product and offcuts. There is technology to separate the gypsum from the paper. However, it is perceived as too expensive and the business does not want to take on the liability.

The Western Cape does not have a large enough industry for certain material types to warrant specialised recyclers to set up operations in the region. WISP's textile waste solution provider has a facility outside Durban in KwaZulu-Natal. The volumes of textile waste do not warrant setting up a processing plant in the Western Cape without external funding which it is not currently able to obtain.

Although the Western Cape has shown a growth in large volume food / organic waste solution providers (Waste2Energy, Waste2Food; Waste2Soil), there is still a lack of viable small-to-medium scale organic food solutions. Obtaining economies of scale to enable financial viability may be prevented by logistical barriers (need for infrastructure for aggregation, need for storage), which link back to capital and operating cost, and attendant returns on investment. This is currently limiting many smaller organic waste streams that could potentially be used for a value add application from being used.

Conversely, the enabling nature of investment in technology to overcome logistical barriers is illustrated by the following case. Until recently, expanded polystyrene (EPS) was a problem waste, contaminated EPS in particular. Companies producing large volumes did not have a solution for EPS as the tonnages and lack of market did not warrant separation. EPS is a high volume low tonnage waste. Since 2014, an EPS recycler was established to collect and, in the near future, process EPS into home decor. Currently, the polystyrene (PS) is extruded and transported to Johannesburg. Extrusion makes the polystyrene denser and greatly reduces the volumetric space it takes up during transportation thereby making the logistics of moving the material feasible. In this case, a technological investment has turned a logistical barrier into a viable one.

All of the above serve to illustrate as well the interlinked nature of economic, technical and logistical barriers.

3.3.2 Case study 2: Logistics

There are numerous examples where logistics is a constraint to realising an exchange of material. A large steel foundry produces large volumes of foundry sand, classified as hazardous, that is send to landfill. There is a licensed solution in the form of a cement producer, that is roughly 100km away. The foundry sand can be used as substitute for the silica material. However, as the density of the waste is so high, transporting such a tonnage is too expensive, more so than sending to landfill.

WISP also has an anaerobic digester (Waste2Energy) solution on its database that is looking to source organic food waste. However, in order to be financially viable, they can only collect organic material within a 50 km radius of operations. As this potential solution is based beyond 50 km of Cape Town, it cannot service the City and its large organic waste producers.

Both of these examples again illustrate the intertwined nature of logistical and economic barriers.

3.3.3 Case study 3: Legislative

Paper fibre recycling companies (paper / cardboard) that are WISP members produce a sludge by-product from the recycling process. This is a mix of short fibres, inks, starches, metals and mostly water. As this industry waste is classified as hazardous, the solution provider must be a waste licensed operator. There is scope to delist paper sludge as a hazardous waste. WISP has several, unlicensed, potential solution providers (this includes building product manufacturers and anaerobic digester (AD) facilities) who are capable of utilising the paper sludge without any detrimental impact to the environment or people. However, these solution providers are not willing to invest in waste licences for other organisations' wastes.

WISP has found that many small-scale recyclers and buyback centres are wary of increasing capacity so as to keep below the legal thresholds for the need for waste licences. WISP currently has a composting company, pallet recycler and a number of buyback centres that do not want to expand operations beyond legal thresholds. This is predominantly a financial reason where such licences are expensive ventures, especially for small businesses. This has resulted in limitations for WISP and its solution providers.

Both these examples also illustrate the intertwined nature of legislative and economic barriers. Unless legislation specifically makes a particular activity illegal, it is to some extent a financial barrier: the costs and attendant time delays associated with obtain the necessary licences / permits for legal operation weaken the business case for pursuing the synergy.

3.3.4 Case Study 4: Capacity

WISP has several composting, pallet recyclers and buyback centre members that, for financial and legislative reasons, are not looking to increase operations and subsequently do not have the capacity to either recycle or collect greater volumes.

Several solution providers do not have capacity to store certain waste streams on site, and are not willing to expand operations for financial and legislative reasons. Buy-back centres are unwilling to sacrifice space to handle low value waste streams (Tetrapak, EPS, food/organics) versus more valuable materials (PET, LDPE, HDPE, glass, paper, and metals).

Waste management is not a key priority for many companies, especially SMMEs. As such, companies do not have dedicated waste management operations, but rather outsource to waste management companies. Waste management falls under the responsibilities of some other overarching management. WISP has a company that has large volumes of mixed general waste, including high value recyclables. As the municipality collects this waste and this is covered as part of the general rates bill, there is no explicit cost to the company. The company has an interest to divert, however, the management responsible for waste management is also responsible for the running of the security and operations, which leaves little time for waste management.

3.4 Resource Barriers and Enablers

The top three resources based on quantity (large) were taken from the WISP database. The barriers and potential solutions that can allow for the reuse/recycling of these resources are listed in Table 1 below. The table shows illustrates that potential synergies are hampered by more than one barrier and again shows how interconnected barriers are.

Table 1: Summary of barriers and enablers associated with certain resources on the WISP database.

Resource	Barriers	Potential Solutions
Paper Sludge 20000 tonnes/year	Legislative: • Processing and treatment thresholds for Category B wastes as defined by the NEMWA exceeded and a waste management licence is required Technical: • Paper sludge contaminated with metals making unsuitable for some processes. • Fibres too short to be reused for the same process Financial: • To acquire a waste management licence, an EIA is required. This is financially costly and time consuming. • Lack of access to funding. Logistics: • Material is 60% water adding to the weight which makes it very expensive to transport	Legislative, Financial: • Industry associations can motivate for the delisting of paper sludge as a hazardous material. • Source and end user companies can co-fund the licences. • Engaging with competent authorities on issues of financing, organisations like GreenCape, various other private and governmental departments can give guidance concerning financing and legislative issues. Technical: • Matching the resource to the right industry. • Since the material is 60% water, it can be ideally used in processes that require water as part of the feed e.g. brick manufacturing • Short fibres are easily digested by anaerobes, which makes it a good feed for ADs. Logistics: • Use of reverse logistics, companies can take advantage of loading capacity of transportation vehicles e.g. a truck that goes one way fully/partially loaded and comes back empty or partially loaded.
Glass Fines 8,000 tonnes/year	Technical: • The glass fines are too fine to be used for the glass making process • Contaminated with stones, paper, soil etc. and thus not suitable for reuse. Financial: • Lack of Research and Development budgets to test material for alternate uses (including infrastructure, man-power). • Access to capital hampers the birth and	Technical: • Alternative use in the construction industry e.g. cover material, brick manufacturing etc. Financial: • There is already a substantial amount of research done on glass fines elsewhere e.g. in Europe. Most of the time the information is readily accessible on the internet • Forming partnerships with academia

	growth of businesses. Capacity: • Due to the sheer volumes produced, there is often more material produced than can be taken by off-takers. • To reduce the complexities of dealing with multiple solution providers and the associated work that comes with synergy implementation, businesses prefer working with a few companies as it makes it easier to manage relationships. Logistics: • Heavy material that is very expensive to transport.	and cross collaboration with other companies that have the capability to conduct research and development projects. • Engaging with competent authorities on issues of financing, organisations like GreenCape, various other private and governmental departments can give guidance concerning financing and legislative issues Capacity: • Companies can form collectives when it comes to dealing the resource producer and handle the distribution amongst themselves after they have acquired the resource • Logistics: • Shared transport to reduce cost
Foundry Sand 72,000 tonnes/year	Legislative: • Processing and treatment thresholds for Category B wastes as defined by the NEMWA exceeded and a waste management licence is required Technical: • The particle size of the sand limits where it can used, usually too fine for some processes and too coarse for some • The sand is contaminated with coal which giving it a black colour, some companies not interested because it ruins aesthetics of their products, some products can be given different colours which would be very hard if the product is already black e.g. tile manufacturers Financial: • To acquire a waste management licence an EIA is required. This is financially costly and time consuming. • Access to capital, both starting and working capital. Logistics: • The material is located far away from the City where the largest potential for reuse is (transporting the material becomes really expensive)	Legislative, Financial: • Industry associations can motivate for the delisting of foundry sand as a hazardous material. • Source and end user companies can co-fund the licences. • Legislators and policy makers need to review these type of materials on a case by case basis to make sure materials are not wrongly classified • Engaging with competent authorities on issues of financing, organisations like GreenCape, various other private and governmental departments can give guidance concerning financing and legislative issues Technical: • Matching the resource to the right industry: whilst clay brick manufacturers are not able to use it, cement brick manufacturers might be able to use the material Capacity • From literature, the biggest reuse of foundry sand has occurred in the construction and cement industries. Interventions from Government to encourage the uptake of this material in these industries. Due to the large volumes produced, this would be an ideal and sustainable solution.

4. CONCLUSION

The Western Cape and South Africa in general are not unique: businesses trying to implement IS world over grapple with similar issues that South Africa deals with. A comparison of the barriers cited in the literature review to the barriers that WISP has come across confirms this. The biggest driver is whether a business case can be made for the resource or synergy. Businesses will use measures like return on investment, payback period and whether the initiative is in alignment with business's interests to make decisions on synergies. It is also evident from the analysis and case studies presented here, that it is difficult to decouple the various barriers and generally these link to finance. There is a financial aspect embedded in the barriers which most of them can be overcome with money. However, such money will not be made available if there is not a strong business case for a synergy and a willingness of the company to potentially expand / adjust its activities.

Government intervention on policy & regulation, infrastructure development (e.g. reduce logistics costs) and awareness raising are key to unlocking some of the opportunities identified through IS. The government and industry bodies can work towards creating an enabling environment for IS to thrive. This is particularly true in terms of legislative barriers, as illustrated in a number of the case studies presented. It is also worth noting in this regard that much of the UK National Industrial Symbiosis Programme's success could be attributed to the high cost of landfill (due to a landfill tax and, notably, the tax initially ring-fenced to provide support to businesses, including through the funding of the UK NISP, to divert waste from landfill). The cost of landfill, which changes the business case, awareness of IS as a potential solution and a willingness to engage in business-a-little-less-than-usual are key enablers for IS. Together with assisting in identifying potential synergies and building the business case, WISP works actively on the last two enablers with notable success, yet in South Africa (the cost of compliance with) the legislative environment and the relatively inexpensive cost of landfill disposal remain key challenges that prevent the considerable benefits of IS to be realised at scale.

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