Potential Uptake and Impact of Industrial Symbiosis within the Western Cape to Aid in Waste Diversion from the Agri-processing, Chemicals and Metals & Engineering Sectors

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ABSTRACT
The Western Cape Industrial Symbiosis Programme (WISP) uses sector based analysis to understand the under-utilised resources generated in different sectors and potentially utilised by other sectors. This paper outlines WISPs findings for the agri-processing, chemicals and metals & engineering sectors. Two distinct classes of resources have been identified: those specific to the sector generated in large amounts, and those generated by all sectors in substantially lower amounts. WISP's challenge is to "find solutions" for the second group. Extrapolating from resource data for WISP's membership, the metals & engineering sector appears to have the greatest potential for job creation and business benefits from synergies. The construction sector holds the greatest potential for the uptake of resources from this sector. To enable the economic and job creation benefits of resource synergies between companies in these two sectors to be realised, joint rather than separate sectoral efforts and initiatives are recommended.

1. INTRODUCTION & BACKGROUND

1.1 Increasing the impact of industrial symbiosis through a sector-based approach

Industrial symbiosis is a resource efficiency approach where unused or residual resources (e.g. material, energy, water, waste, assets, logistics, expertise) of one company are used by another. This typically results in mutual economic, social and environmental benefits.

The Western Cape Industrial Symbiosis Programme (WISP) is a free facilitation service that connects companies so that they can identify and realise the business opportunities enabled by using unused or residual resources. WISP builds a network of companies and identifies under-utilised resources that could lead to business opportunities for other member companies. These business opportunities aid in the diversion of materials from landfill, promoting resource efficiency, while growing the (secondary materials) economy and potentially creating new jobs and new enterprises.

Industrial symbiosis (IS) has been implemented in many different countries to achieve different objectives (see Chertow, 2004). In some regions, it is used to achieve environmental goals (e.g. increasing recycling rates, landfill diversion), whereas in others it enables particular forms of economic development (e.g. eco- industrial parks). In the UK, for example, the National Industrial Symbiosis Programme (NISP) was established in 2005 as a programme to support landfill diversion, initially linked to the collection of a landfill tax and an associated landfill tax fund. Passed into law in 1996, the landfill tax set an escalating tax on industrial landfill, which in 2008 was 32 GBP/tonne (approx. R 750/tonne at today's rates) and expected to rise to 48 GBP/tonne (approx. R1000/tonne at today's rates) by 2010 (Paquin and Howard-Grenville, 2009). The primary funding for the programme was provided through the UK Department of Food, Environment and Rural Affairs (defra). Landfill diversion and carbon emission reductions were key performance indicators (Laybourn and Morrissey, 2009).

WISP has adopted the facilitated approach to industrial symbiosis developed for the UK NISP. WISP's funding is provided through the Western Cape Government's Green Economy initiative and administered through the Department of Economic Development and Tourism (DED&T). As such, the programme is primarily required to achieve economic development (through cost savings to /increased sales by/new investment by businesses) and job creation. However, landfill diversion and carbon emission reductions are also reported.

In order for WISP to attain its goals, WISP facilitators focus primarily on the manufacturing sectors of the Western Cape i.e. WISP focuses on industrial waste arisings rather than post-consumer waste. When compared to post-consumer wastes, waste arisings from industry are generally more homogenous (or more readily segregated) and less disaggregated (i.e. larger volumes of waste are available in one place). In theory, these wastes are thus more readily returned to the economy than post-consumer waste. WISPs facilitation is sector-based, rather than area focused, as implementing IS within a finite boundary results in challenges when trying to optimise IS (e.g. fewer companies in a small area with fewer potential solutions). Synergies typically occur between companies and a particular "solution provider" (i.e. a company that has been set up specifically to process particular materials and make them available for reuse) or directly between companies in different sectors. WISP's sector-based approach to facilitation in theory promotes replicability of synergies as resources being produced or needed by companies in a particular stage of the value chain within a particular sector should be similar across all the companies in that stage of the value chain in that sector. By implication, the synergies realised and their impacts (in terms of business benefits, environmental benefits, job creation etc.) could be expected to be similar (depending, among others, on the scale of the resource). Therefore, replication of synergies is one of the main strategies to accelerate the impact of WISP. Sector based analysis to understand the under-utilised resources generated and potentially utilised by other sectors, the patterns of synergies and the attendant impact of these synergies is thus key to identifying opportunities for scaling impact including through replication. This paper outlines WISPs findings with respect to resources available in three key sectors of the Western Cape economy, namely agri- processing, chemicals and metals & engineering. It attempts to understand the potential for industrial symbiosis in these sectors, the patterns of potential synergies for the resources in these sectors, the potential benefits that can be gained from realising and replicating these synergies and the barriers that may prevent these benefits from being realised.

1.2 Manufacturing Sectors in the Western Cape

The Western Cape manufacturing sector is diverse. Manufacturing output can be measured in terms of real value added (RVA) to the economy. The below table outlines which sectors exist within the Western Cape, as well as their relative RVA.

Table 1: Secondary Sector contributions to real value added (RVA) in the Western Cape (Laubscher, 2011)

Secondary Sector	Percentage contribution to relative value add (RVA)
Food & Beverages – agri processing	28.2
Petroleum products, chemicals, rubber & plastic	20.8
Metals & engineering (incl. machinery)	12.7
Wood, paper, printing & publishing	10.1
Other industries	8.4
Clothing & textiles	5.3
Motor vehicles, parts & accessories	4.3
Glass & products and other non-metallic minerals	3.7
Electronics (excl. ICT)	2.7
Other transport eqp (incl. boat building)	1.5
Furniture	1.3
Leather & products and footwear	1.0

Close to half of the regional manufacturing sector output in the Western Cape is produced in two sub- sectors, namely agri-processing ("food and beverages", 28.2%) and petrochemicals ("petroleum products, chemicals, rubber & plastic", 20.8%). "Metals & engineering (incl. machinery)" has the third highest contribution to the RVA in the Western Cape. These sectors have thus been targeted for an initial sector based analysis assuming that greater manufacturing activity could also lead to greater opportunity for IS and scaling of IS benefits. Similar analyses are underway for the other sectors of the Western Cape economy.

2. SECTOR ANALYSES – MAJOR UNDER-UTILISED RESOURCES IN KEY SECTORS AND POTENTIAL SYNERGIES

2.1 Motivation and Approach

The sector analyses were done to assess the potential of IS within each of the sectors and to identify replicable synergies. The first step was to identify the under-utilised materials arising from the target sectors. Data was gathered from member companies within specific sectors either at business opportunity workshops (where potential members share information about their under-utilised resources and resource needs, and potential synergies are identified) or directly via site visits by facilitators specialising in the particular sector. This data was collated in the IS database platform SYNERGie^{TM} and under-utilised materials classified into the general resource categories used by WISP. These are: Capacity; Coatings and Adhesives; Energy; Expertise; Organic Material (Food & Agriculture); Inorganics; Land; Logistics; Metals; Minerals, Ceramics and Glass; Organic Chemicals; Paper; Plastic; Textiles, Leather & Furs; Water; WEEE; and finally, Wood.

Before presenting the results of these analyses of resources available in each of the sectors, a brief overview of the sectors is provided below.

2.2 Sector Outlines

2.2.1 The agri-processing sector

The agri-processing sector in the Western Cape generally yields high value products, such as wine and other fruit products (e.g. canned fruit, dried fruit, fruit juice), fish products (e.g. packaged processed fish fillets, fishmeal), other animal products (e.g. chickens and chicken products; pork and pork products), dairy products (e.g. milk, yogurt, cheese) and other processed food products (e.g. soups, pies, sauces). Many large companies exist within this sector. However, these companies are made up of many subsidiary companies scattered around the Western Cape (and rest of South Africa). These subsidiaries operate multiple manufacturing/processing facilities also scattered around the Western Cape (and rest of South Africa). As part of its sector based strategy, WISP engaged with twenty one (21) member companies in order to understand their manufacturing processes, as well as what by-products/waste streams their processes yield.

2.2.2 The chemicals sector

The Chemicals industry covers a broad range of activities and products. Almost all industries (including health, mining and minerals processing, agriculture and agri-processing, other industries in the same value chain and water treatment) rely on this sector. In the Western Cape, there are two major petro-chemical facilities and some manufacture, processing and/or distribution of plastics, rubber, and various organic and inorganic chemicals including bio-chemicals and pharmaceuticals. As part of its sector based strategy, WISP engaged with twenty five (25) member companies in order to understand their manufacturing process, as well as what by-products/waste streams their processes yield. (It is worth noting that some of the companies sampled are distributors only and hence would strictly be considered part of the tertiary / services sector, but have been included as these companies still give rise to wastes associated with the primary product (e.g. expired chemicals)).

2.2.3 The metals and engineering sector

The metals & engineering (M&E) sector of the Western Cape encompasses a wide variety of industries: from the manufacture of raw steel to the recycling of scrap metals, as well as the fabrication of purpose-built machinery for use in industry and at the home. As part of the sector based strategy, thirty six (36) member companies across all manufacturing stages of this sector were engaged by WISP to understand their process, as well as what by-products/waste streams their processes yield.

2.3 Resource Availability – Comparison across Sectors

The information on the by-products/waste streams from agri-processing (21 companies), chemicals (25) and metals & engineering (36) member companies collected by WISP facilitators was analysed to identify the largest resource streams by mass per sector. The results of this analysis is summarised in Figure 1 and Figure 2.

It is worth noting that the analysis is based on a sample of companies in each of the sectors that has been gathered in an opportunistic way, i.e. based on companies participating in WISP workshops and those willing to engage with WISP through site visits. The sample is thus not comprehensive or necessarily representative of each of the sectors in the Western Cape. Furthermore, the sectors differ in scale (e.g. throughput of materials) and nature (type of materials) and different numbers of companies have been included in the analysis - the least for agri-processing (21) and the most for metals & engineering (36). For this reason any comparisons across sectors should be considered indicative and interpreted qualitatively rather than quantitatively i.e. as indicating likely general trends. However, some conclusions can be made about the quantities of resources available in different sectors in the WISP network specifically and the attendant potential (in different sectors) in the WISP network, rather than in the sectors as a whole. Work to expand the sample size and gain a more representative sample is on-going

Figure 1 depicts largest under-utilised resource streams by mass in each of the three sectors and the amount of these generated by the other sectors. Figure 2 excludes the resources depicted in Figure 1, and depicts the next three largest resource streams by mass considering all three sectors and again shows these for all three sectors. This split in representation was informed by the observation that there appears to be two distinct classes of resources: those that appear to be specific to the sector and generated in great amounts by the companies in those sectors (Figure 1) and those that appear to be generated by all sectors, but in comparatively lower amounts (Figure 2). (Note in particular the different scales in the two figures).

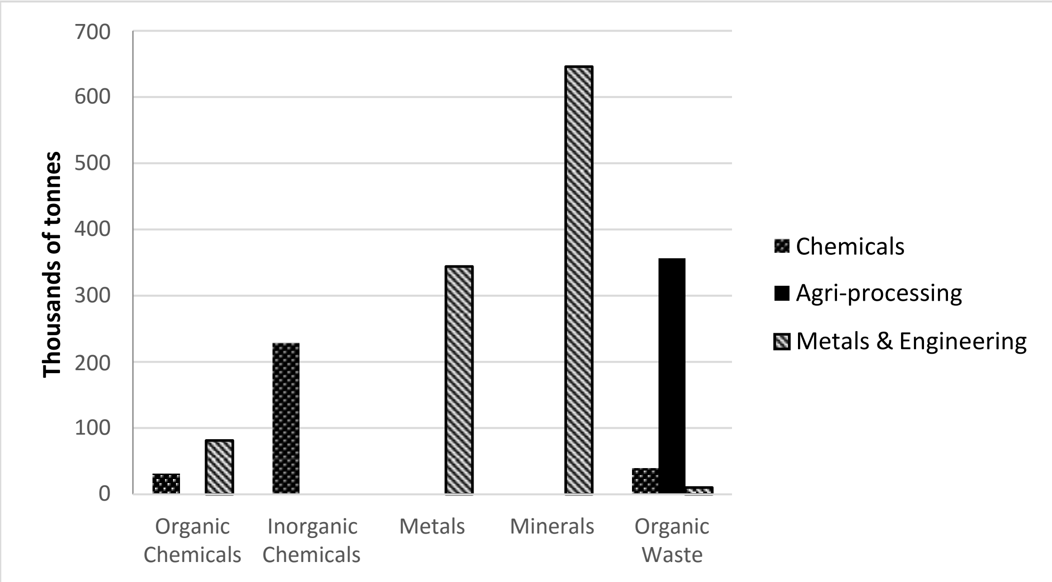

Figure 1: Top three resources by mass (i.e. ranking 1 – 3) for the agri-processing (21 companies), chemicals (25 companies) and metals & engineering (36 companies) members in the WISP network.
Note: the y-axis in demarcated in hundreds (of thousands of tonnes).

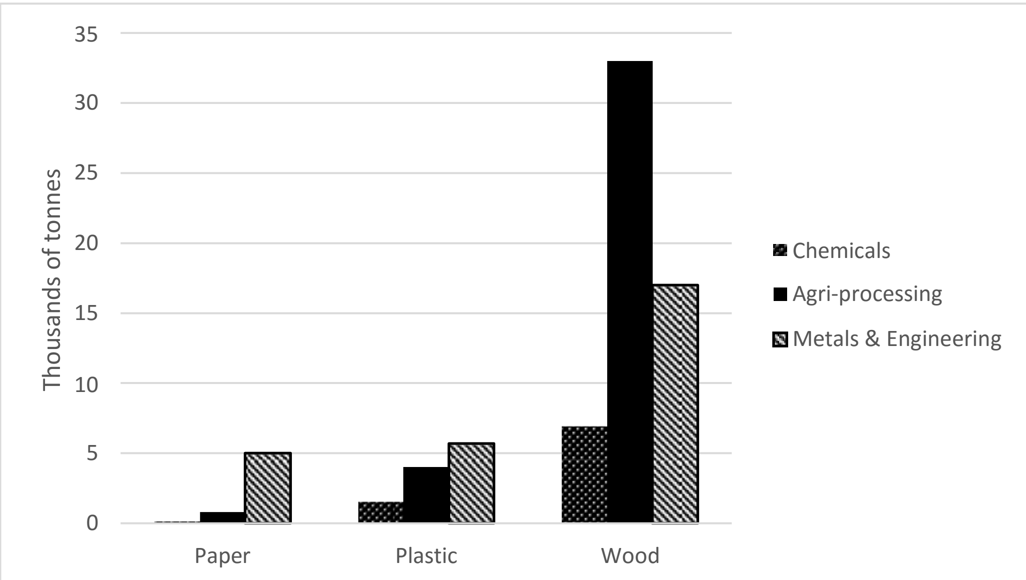

Figure 2: Next top resources by mass (i.e. ranking 4 – 6) for the agri-processing (21 companies), chemicals (25 companies) and metals & engineering (36 companies) members in the WISP network.
Note: the y-axis in demarcated in hundreds (of thousands of tonnes).

Figure 1 indicates that the companies in the chemicals sector produce the largest amount of waste inorganic chemicals; those in the metals & engineering sector, the largest amount of metals and mineral wastes; and those in the agri-processing sector the largest amount of organic wastes, with the other sectors not producing significant quantities of these “characteristic resources” of the other sectors. (An exception here is the metals & engineering sector, which produces a large amount of organic chemical wastes. These are typically waste organic solvents. Given the skewed sample set (i.e. larger number of companies sampled in this sector) and the sheer scale of throughput in this sector, this observation is not considered to undermine the general trend observed.) The second group of resources (highlighted in Figure 2) could be considered common “dry recyclables” that are also typically found in post-consumer waste. These typically arise from non-core activities (e.g. transport and packaging of feedstocks and products).

The larger amount and specificity of waste to specific sectors supports the case for industrial symbiosis as a strategic intervention to divert waste from landfill and a core focus area for returning waste materials / resources to the economy. Dry recyclables (Figure 2) are ubiquitous and the secondary materials value chains (e.g. glass-, paper-, plastics- recycling) are fairly well established for these materials in South Africa. IS brings the advantage of larger, more readily separable (on site) dry recyclable resources to scale the well-established secondary materials economy associated with these materials. In this manner, IS can make a contribution to economic development and job creation by scaling up the activities in these well-established secondary material value chains. At issue for WISP is whether IS can be sufficiently successful and the local demand for secondary materials sufficiently large to attract more of the processing (i.e. manufacturing) activities for these secondary material value chains to the Western Cape to enable direct benefit to the local economy from locally arising under-utilised resources.

The challenge for WISP is thus to “find solutions” to the characteristic under-utilised resources of different sectors. Extrapolating from the relative amounts of these, it can be argued that these present the largest opportunities (e.g. for landfill diversion, economic development and job creation), as well as the largest challenges (technical, financial, regulatory etc.). The potential solutions, scale of opportunity and challenges in each of the target sectors are discussed next.

2.4 Potential synergies and associated challenges for the characteristic resources in different sectors

2.4.1 The agri-processing sector – opportunities and challenges

Within the agri-processing sector, well-established solutions exist for the processing and value add to organic waste resources. Many agricultural residues are diverted to animal feed, a high value product. Examples of such practices exist in the juicing industry, whereby fruit pulps are added to feeds to supplement the growth of livestock. Other solutions exist in the form of composting, anaerobic digestion or value addition through fly farming. Anaerobic digesters are efficient, large volume “processors” of organic waste, yielding energy in the form of a combustible gas that can be used for cooking, heating, electricity generation or transport. Fly farming too has the potential to process large volumes of organic waste, while yielding high value products in the form of high protein content animal feed and fertilisers. Composting aerobically breaks down organic material in to high nutrient, high value fertilisers utilisable as soil supplements in agriculture. All of the above solutions are scalable and thus have the ability to process large volumes of organic waste. Composting as a solution can also accept certain inorganic chemical waste streams such as various types of coke, calcium sulphates, ammonium nitrates etc., which presents an opportunity for cross-sector synergies: for example inorganic chemicals from the metals & engineering sector are already utilised by established composters within the agri-processing sector.

The generally de-centralised nature of organic waste steams presents a challenge for WISP and the implementation of IS in the Western Cape. The lack of economies of scale and the high cost of logistics to aggregate to achieve scale, as well as the relatively low cost of landfill weakens the business case for potential solution providers. Legislative hurdles exist too for new companies wishing to set up as solution providers. These include the requirements for waste licences for transport/storage of waste materials on site and the requirements for air emissions licences for processing facilities. These requirements apply if quantities of waste are above certain thresholds or a particular type of waste (e.g. abattoir waste) is to be processed. Licence requirements are important to ensure environmental protection, but add cost (including for additional infrastructure and costs associated with licence applications e.g. for environmental impact assessments) impacting on the business case, especially for SMMEs and new entrants. The timeframes required to obtain the various licences before being able to commence with business may also affect the feasibility of projects (e.g. ability to access capital loans due to increased uncertainty about commencement of operations and ability to pay debt). The convenience and low cost of landfill also provide disincentives for generators of organic waste to consider alternative solutions.

2.4.2 The chemicals sector – opportunities and challenges

The available solution providers for inorganic chemicals do not have the capacity to take the large quantities of inorganic chemicals available. Industrial organic chemicals comprise mainly solvents and alcohols that can be used as fuels as a last resort when recovery is not economical. Current solutions for the recycling of organic solvents exist in the form of recovery by filtration and distillation. An existing WISP member is capable of recycling large volumes of organic solvents, highlighting the significance of the contribution made by solution providers. Inorganic chemicals on the other hand cannot be employed in waste-to-energy activities as their calorific value is very low. In fact, those that do decompose are net consumers (i.e. undergo endothermic reactions) of energy during decomposition. These materials are usually found as salts, carbonates, sulphates, nitrates, silicates etc. existing in solid and aqueous form (slurries e.g. slaked lime from industrial gas production). Some of the materials could find use in the agricultural and construction industries. Technical challenges (e.g. removing any contaminants, dewatering to make transport economical) as well as legal requirements for storage, transportation, recovery and reuse of these by-product streams poses the biggest barriers to their uptake, as there is a financial aspect associated with it (as described for organic wastes above). In addition, landfilling costs are still not high enough to discourage the resource generators from sending material to landfill and to encourage them to consider alternative solutions.

2.4.3 The metals and engineering sector – opportunities and challenges

The construction sector offers many solutions for materials arising within the metals and engineering sector. Solutions to minerals arising in the metals and engineering sector include brick and tile manufacturers, road construction (e.g. as aggregate replacement) and cement manufacturing. Examples of potential synergies are the use of foundry sand as backfill at a sand mine, as a raw material in cement manufacture, in road building applications and cementitious products such as cement bricks. Each of these solutions has the potential to divert a significant proportion of the resource from landfill.

Implementation of the above synergies has been met with challenges and thus proven to be unachievable as yet. For example, this specific material (foundry sand) is classified as a hazardous waste, although it is possible to remove the hazardous content from the foundry sand through mechanical separation. There are thus costs associated with infrastructure and licencing to enable this material to be used and as yet, with the low cost of landfill and the cost and proximity of virgin resources, the business case is not strong enough for either member of a potential synergy to consider investment in processing infrastructure. There are legal challenges involved with delisting the material (as hazardous), which has a time implication (i.e. it is likely to be a number of years before IS solutions can be implemented readily). Another challenge exists in the logistics of moving the material, as it has a high relative density, along with it being a bulk arising (similar to the inorganic chemicals category in the chemicals sector), making it difficult for a single solution provider to handle. Many producers of bulk / large scale wastes prefer to deal with one solution provider rather than a large number of smaller ones which can exclude those who could potentially be solution providers for some, but not all, of the material.

2.5 Potential Scale of the Opportunity

Facilitated sector-based IS has resulted in WISP achieving, among other things, more than 2200 tonnes of landfill diversion and a total of 22 permanent jobs created since inception of the programme (Table 2). Based on this, the general assumption can be made that for every 100 tonnes of waste diverted from landfill, one permanent job would be created. Based on this assumption, a rough estimate can be made of the potential for job creation within the agri-processing, chemicals and metals & engineering sectors. (It is recognised that this number would be highly sector specific and it is the intent to generate sector specific multipliers in future. The estimates presented here are thus considered indicative at this stage.)

Table 2 also displays the costs per tonne of disposing general waste to landfill. Diversion of wastes from landfill thus have a direct economic benefit to companies, in that they can be assumed to display cost savings of R 395.40 per tonne of general waste (based on the City of Cape Town gate fee for 2016 since the majority of WISP members are in the greater Cape Town area). When considering the amounts of the top three resources in Figure 1, the cost savings potential (see Table 3) is significant.

Table 3 displays the economic and job creation potential per sector based on the top three resources produced by all three sectors. Both potential job creation and potential cost savings are significant for all three sectors; however an indication of the likelihood of these cost savings and jobs created coming to fruition is provided based on the facilitators' targeted engagement of companies within the sectors.

Table 2: WISP achievements to date (April 2013 – May 2016)

Key performance indices	Cumulative to date(April 2013 – May 2016)
Waste Diversion	2200
Landfill Cost per tonne of general waste	R 395.40
Cost Savings	R 0.8 million
6200	Tonnes
2200	Tonnes diverted from landfill
Fossil GHG Savings	
1.80 Wind	turbines installed
Job Creation	15 Temporary jobs
22	Permanent jobs

Table 3: Sector economic potential and likelihood of realising this potential based on top three resources for WISP network members in the agri-processing, chemicals and metals & engineering sector (presented in Figure 1)

Sector	Potential Jobs Created	Potential Cost Savings	Likelihood of Realisation
Agri-processing	3560	+- R 140 Million	Med - high
Metals & Engineering	9900	+- R 390 Million	Low - med
Chemicals	2630	+- R 100 Million	Low

Table 3 suggests that the largest opportunity for job creation and business benefits from WISPs current membership is in the metals & engineering sector. However, this is also the sector that poses the largest challenges (least likelihood of realisation) due to the bulk nature of the waste and (costs associated with) legal requirements. Although WISP can continue to work on company-to-company basis to drive synergies, it is expected that, to drive real progress in waste diversion and realise the business benefit potential inherent in these under-utilised resources, action at an industry, association level is required. However, this needs to be driven by the associations of both those who have the resource and those who would be capable of using it. In the case of metals & engineering, the construction sector (brick making, tile making, road construction, cement making) holds the greatest potential for the uptake of under-utilised resources from the metals & engineering sector (metals/minerals processors, foundries). Both can make an argument for a more enabling regulatory environment based on the safeguarding of their industries (against rising costs) and the economic and job creation potential that can be realised. The environmental benefits (landfill diversion, carbon emission savings from replacement of virgin resources, avoiding environmental damage associated with leachate generation etc.) also needs to be determined to build the case. For consideration is whether a joint / cross-sectoral rather than separate efforts could strengthen the case. For consideration too, is whether there are other enablers (e.g. working towards standards for construction materials being inclusive of secondary materials; (funding) pilots to demonstrate benefits; R&D to develop economical processes to enable reuse etc.) that could be initiated by the industry that would strengthen the business case and thus realise the business, economic and environmental benefits that could be enabled by synergies between these sectors.

3. CONCLUSION

The analysis of the under-utilised resources arising from WISPs members in the agri-processing, chemicals and metals & engineering sectors has demonstrated that there are two distinct classes of resources: those that appear to be specific to the sector and generated in great amounts by the companies in those sectors, and those that appear to be generated by all sectors, but in substantially lower amounts. The latter are “dry recyclables” (e.g. paper, plastics, wood) for which the recycling industry is fairly well established in South Africa. WISP brings the advantage of access to larger, concentrated amounts of dry recyclable resources. In this manner, WISP can make a contribution to economic development and job creation by scaling up the activities in these well-established secondary material value chains. The challenge for WISP is thus to “find solutions” to the second group of resources, i.e. the “characteristic” under-utilised resources of different sectors. Extrapolating from the relative amounts of these, it can be argued that these present the largest opportunities (e.g. for landfill diversion, economic development and job creation), but there are also challenges (technical, financial, regulatory etc.) to realising synergies for these resources. Of the sectors analysed, the metals & engineering sector in WISP membership network was estimated to have the greatest potential for job creation and business benefits. Although WISP can continue to work on company-to- company basis to drive synergies, it is expected that, to drive real progress in waste diversion and realise the business benefit potential inherent in these under-utilised resources, action at an industry, association level is required. As the construction sector (brick making, tile making, road construction, cement making) holds the greatest potential for the uptake of under-utilised resources from the metals & engineering sector (metals/minerals processors, foundries), it is proposed that joint / cross-sectoral rather than separate efforts are needed to overcome (particularly regulatory) challenges, but also catalyse initiatives that would strengthen the business case and enable the business, economic and environmental benefits of resource synergies between companies in these sectors to be realised.

WISPs further work in this area will be to expand the sample sets in these sectors to work towards an analysis that is representative of the sectors in the Western Cape, rather than WISPs membership of those sectors, and to expand the analysis to other sectors. As more synergies are realised in these sectors, the aim is also to generate more refined sector specific estimates of job creation, business and environmental benefits, so as to enable WISP, and other industrial symbiosis programmes in South Africa, to work in a more targeted manner to scale the economic, environmental and job creation impact enabled by industrial symbiosis and realise its full potential as an approach to the effect a transition from a waste economy to a resource economy in South Africa.

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