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INDUSTRIALISATION AND SUSTAINABLE GROWTH

THE NATURE AND ROLE OF INDUSTRIAL SYMBIOSIS IN SOUTH AFRICA

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Abstract

Industrial symbiosis has the potential to drive sustainable growth within the industry in South Africa, generating business benefits for the companies involved and economic benefits of value to the government. Industrial symbiosis activities have grown substantially in South Africa over the last three years. A key contributor has been the development of three regional facilitated industrial symbiosis programmes (ISPs) in South Africa, GISP (based in Gauteng), KISP (based in KwaZulu-Natal) and WISP (based in the Western Cape). Over the next three years, the existing programmes are expected to grow and mature, significantly increasing their impact year-on-year. New programmes are also expected to develop around the country in less industrially dense regions of South Africa.

Drawing on the experience of WISP, the most mature of the industrial symbiosis programmes in South Africa, this paper outlines how facilitated industrial symbiosis supports sustainable industrial growth in South Africa based on the economic, environmental and social business benefits generated through resource exchanges or 'synergies'.

Further to this, this paper explores the role of facilitated industrial symbiosis programmes driving economic development and job creation. Four roles are examined: (i) unlocking value by creating economic of scale and clustering resources; (ii) increasing the competitiveness of industry by driving innovation; (iii) driving market led enterprise development and (iv) assist creating eco-industrial parks in South Africa.

Finally, key enablers are presented for the embedding of industrial symbiosis in South Africa with a particular focus on the role of stakeholders and the policy and regulatory framework.

Key words: industrial symbiosis, industrial ecology, circular economy, recycling, waste minimisation, waste beneficiation, waste economy

About the authors

Sarah O'Carroll

Sarah joined GreenCape in 2013 as a Western Cape Industrial Symbiosis Programme (WISP) facilitator where she subsequently took over as programme manager in 2014. With the help of her team, Sarah is championing Industrial Symbiosis in the Western Cape as a key for the development of a sustainable manufacturing industry in the Western Cape and beyond. By facilitating the exchange of unused resources between companies, the programme assists to turn waste streams into secondary materials, returning them into the economy, rather than being lost to landfills. These resource exchanges or 'synergies' reduce the carbon intensity of the manufacturing industry and improve resource efficiency. Sarah was instrumental to the establishment of the other regional facilitated industrial symbiosis programmes in Gauteng and KwaZulu-Natal. Further to this, Sarah's involvement at GreenCape has extended into enterprise development, where she has developed a programme with South African Renewable Energy Business Incubator (SAREBI) to develop SMMEs using business opportunities identified by WISP.

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Lauren is GreenCape's Manager: Technical and Knowledge. In this capacity she provides strategic and technical support to GreenCape's energy, water, waste and agriculture programmes, and co-ordinates their knowledge generating activities. In addition, Lauren's role is to broker links to knowledge and innovation institutions to support GreenCape activities and those of its member companies. Lauren holds BSc and MSc degrees in Chemical Engineering from the University of Cape Town, South Africa and a PhD in Chemical Engineering from the University of Sydney, Australia. Prior to joining GreenCape in 2013, Lauren worked industry and academia in South Africa, Australia and the United Kingdom. Lauren was the Project Manager for the Western Cape Industrial Symbiosis Programme (WISP) during its pilot year in 2013/14, as well as Project Manager for the 2014/2015 British High Commission Prosperity Fund project to support the development of a National Industrial Symbiosis Programme in South Africa.

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Jarrod joined GreenCape in 2015 as facilitator within the WISP programme. Jarrod holds a BTech in Oceanography at the Cape Technikon and a MSc in Molecular Biology from the University of Cape Town. Within WISP, Jarrod has specialized in value-addition to organic residues from the agriculture and food & beverage industries and biogas applications. Jarrod supports the expansion of the green economy in the Western Cape acting as one of GreenCape's investment promotion liasons. Jarrod is also a mentor to SMMEs in the Global Cleantech Innovation Programme (GCIP), a global initiative that aims promotes clean technology innovation and supports SMEs and startups to enter the global marketplace.

Sam Smout

Sam completed his degree in environmental management at the University of KwaZulu-Natal in 2012. From 2012 to 2014, he worked as an environmental consultant at Jeffares and Green (now JG Afrika), a South African engineering and environmental consulting company. In 2014, Sam joined GreenCape's Western Cape Industrial Symbiosis Programme (WISP) as a facilitator, focusing on the diversion of organic wastes from landfill and providing market intelligence to the network's solution providers. At the end of 2016, Sam left WISP and took up the role of GreenCape's waste sector desk analyst. His primary role is to engage with various stakeholders (business, government, academia, and NPOs) in the waste and secondary materials industries. This to understand the opportunities for, and barriers against, investment in green technologies, systems or processes that contribute to beneficiating waste in the Western Cape, with the overall goal being to support GreenCape's vision for a green economy.

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Henry is a Project Manager at the National Cleaner Production Center of South Africa (NCPC-SA). He holds an MSc in Environmental Management from the University of Johannesburg. He currently heads up the waste portfolio at the NCPC-SA, that includes the delivery of GISP. His interests include; the role of waste economy in transitioning South Africa to a green economy; waste innovation; the application of industrial symbiosis; as well as aspects of circular economy and integrated waste management. Henry has provided strategic input in a number of waste related initiatives at the NCPC-SA and related stakeholders, and he is currently working with UNIDO to pilot the Eco-Industrial Park concept in two industrial parks in South Africa to promote resource efficiency and environmental performance.

Contents

Abbreviations

NCPC-SA	National Cleaner Production Centre of South Africa
UK-NISP	United Kingdom National Industrial Symbiosis Programme
WISP	Western Cape Industrial Symbiosis Programme
ISL	International Synergies Limited
BHC	British High Commission
KISP	KwaZulu Natal Industrial Symbiosis Programme
GISP	Gauteng Industrial Symbiosis Programme
SA-NISP	South African National Industrial Symbiosis Programme
ISP	Industrial Symbiosis Programme
GHG	Greenhouse has
SAREBI	South African Renewable Energy Business Incubator
SME	Small and medium sized enterprises
CO_2e	Carbon dioxide equivalents
UNIDO	United Nations Development Organisation
IPRP	Industrial Park Revitalisation Programme
GVA	Gross value add
IDZ	Industrial Development Zone
SEZ	Special Economic Zone
GCIP	Global Cleantech Innovation Programme

1 Industrial symbiosis in the South African context

South Africa's three industrial symbiosis programmes (ISPs) in Gauteng (GISP), KwaZulu Natal (KISP) and the Western Cape (WISP) each provide a free facilitation service that connects companies so that they can identify and realise the business opportunities enabled by using unused or residual resources. These resources include materials, energy, water, assets, logistics and expertise. Each ISP works with its network of companies to implement resource exchanges which may result in business benefits in the form of cost savings, new sales and as a result increased profits. The resource exchanges generate environmental outcomes: waste is diverted from landfill, water re-use or recycling is implemented and carbon emissions are reduced. Economic outcomes may also be realised as opportunities for new enterprise development are identified through the clustering of underutilised or discarded materials and new jobs created through the collection, sorting and cleaning of materials.

The industrial symbiosis facilitators assist businesses by providing the capacity and expertise that companies might not have to identify and realise the potentially beneficial links with other companies, and track the benefits achieved by each resource exchange in order to report on the impact of the programme both for member companies as well as the impact on the wider economy.

1.1 The development of industrial symbiosis activities in South Africa

Industrial symbiosis was first piloted by the National Cleaner Production Centre of South Africa (NCPC-SA) in 2010. Demonstration activities were a success, but there was insufficient government and industry appetite to launch a facilitated industrial symbiosis programme in South Africa at the time.

1.1.1 WISP – the first facilitated industrial symbiosis programme

In 2013, GreenCape, a sector development agency for the green economy in the Western Cape, piloted the Western Cape Industrial Symbiosis Programme (WISP) with funding from the Western Cape Department of Economic Development and Tourism. Although only 59 tonnes of waste were diverted from landfill during the pilot year, significant economic benefits (R5.7 million) in relation to its funding were achieved by the programme and four permanent jobs were created. The Western Cape pilot was deemed a success and a full industrial symbiosis programme was established in 2014.

Much of the success of the pilot can be attributed to GreenCape modelling WISP on the UK National Industrial Symbiosis Programme (UK-NISP) that is delivered by International Synergies Limited (ISL) and continued the support of ISL for the design and delivery of WISP.

1.1.2 Expansion of industrial symbiosis in South Africa and beyond

In 2014, GreenCape, NCPC-SA and International Synergies Limited (ISL) were awarded funds from the British High Commission (BHC) through its Prosperity Fund for industrial symbiosis knowledge sharing and capacity building activities in South Africa, as well as awareness raising in other southern African countries. Key project objectives included:

i. The development of an institutional framework and implementation plan for industrial symbiosis in South Africa
ii. Industrial symbiosis programme scoping and roadmap development for the Gauteng Province
iii. Knowledge sharing and capacity building for industrial symbiosis in South Africa
iv. Awareness raising and knowledge sharing with other Southern African Development Community (SADC) countries

The project resulted in the significant growth of industrial symbiosis activities in southern Africa, catalyzing the development of industrial symbiosis programmes in KwaZulu Natal (KISP) and Gauteng (GISP) and starting a conversation between key national and provincial departments (including Trade and Industry, Environmental Affairs, Science and Technology and Economic Development) for the development of a national industrial symbiosis programme for South Africa.

Knowledge sharing and awareness raising with other African countries through the project as well as other ISL activities has resulted in the initiation of industrial symbiosis programmes in Mauritius, Ghana and Egypt.

Since the completion of the project, demonstration activities by GISP and KISP have confirmed that there is significant potential for industrial symbiosis in South Africa. As these regional programmes are (and continue to be) capacitated with dedicated full time staff they generate increasing business benefits (see Section 2.4).

1.2 The role of industrial symbiosis in the broader South African economy in the context of global industrial symbiosis activities

Industrial symbiosis programmes and activities have been established around the world to achieve different objectives. For some regions, it is chiefly used to drive environmental goals, whereas in others it is has been used to drive economic development, and in others still a combination of economic, environmental and social objectives. The table below provides a brief summary of the role of industrial symbiosis in different regions (Chertow, et al., 2004).

Table 1: The role of industrial symbiosis in regions around the world

Region	Role of industrial symbiosis
Western Europe	Industrial recycling networks, increase recycling rates and diversion from landfill.
Asia-Pacific	Drive the circular economy for economic development where economic and environmental systems are integrated. Development of eco-industrial parks.
South Asia	Most prevalent in the informal economy. Implementation in the formal economy driven through planned resource efficiency programmes.
North America	Development of eco-industrial parks, eco-industrial buildings, waste exchange and by-product reuse.
Africa and Latin America	Development of eco-industrial parks and planned industrial symbiosis activities with an emphasis on economic development and job creation.

Not stated in the table above, industrial symbiosis is largely used in East Europe to drive the development of bio based economies to reduce dependency on fossil fuels (Mirata, 2015).

Industrial symbiosis activities are increasing around the world as industrial ecology practices are adopted. As activities expand, the role of industrial symbiosis in each region does not appeared to change significantly. As indicated by Chertow in 2004, industrial symbiosis activities in Africa has been implemented to drive economic development; this is also true for South Africa.

2 Industrial symbiosis creates triple-bottom-line business benefits

The regional facilitated ISP's in South Africa provide evidence that industrial symbiosis creates triple-bottom-line benefits for the companies involved. These are summarised in Table 2.

Table 2: Economic, environmental and social benefits associated with industrial symbiosis networks[1].

Economic benefits	Environmental benefits	Social benefits
Increase profits Increase sales Reduce waste disposal costs Create enterprise development opportunities Reduce raw material costs Create inward investment opportunities	Reduce CO_2 emissions Divert material from landfill Reduce use of virgin resources Reduce hazardous waste disposal Reduce production of pollution Increase energy efficiency Increased innovative waste management practice	Create jobs Create opportunities for knowledge transfer and learning

2.1 Economic co-benefits

Resource exchanges create financial benefits on two fronts: (i) the potential for additional revenue to be generated from waste materials; and (ii) cost savings from no longer paying landfill gate fees (supplier) or reductions in raw material costs (user).

More than 70% of members in South Africa's ISPs are SMEs. Sustainability continues to largely be seen as a non-core activity within South African companies, particularly within SMEs. The grant funded regional ISPs provide dedicated capacity and technical expertise to identify actionable opportunities, at no cost to the companies. This is particularly significant for SMEs with limited funding, capacity and technical expertise to drive a sustainability agenda. Therefore ISPs play an important role in supporting the greening of SMEs in South Africa that are regarded as the driver for economic development in the country, employing 28% of the population and accounting for 52% of GDP in the country (Bureau for Economic Research: University of Stellenbosch, 2016).

Industrial symbiosis can also be used to drive the development of new businesses as market gaps are identified through facilitation. By understanding where large volumes of materials exist that are not currently serviced by the market and are disposed of at landfill, and having the technical expertise to know how the materials could be beneficiated, ISPs are in a unique position to provide vetted market opportunities to entrepreneurs (see Section 3.3 for more detail).

ISPs therefore increase the overall competitiveness of the local manufacturing industry, driving financial sustainability within companies, increasing local manufacturing potentially via import substitution and waste material beneficiation.

[1] Benefits that can be realised by a facilitated industrial symbiosis programme based on experience and information collected by ISL and collated by WISP (http://www.international-synergies.com/)

2.2 Environmental co-benefits

By finding alternate uses for residual and discarded resources, industrial symbiosis facilitates the return of materials to the economy, rather than being lost to landfill. By promoting the uptake of secondary materials, fossil greenhouse gas (GHG) emission reductions are typically achieved via (i) avoided emissions from no longer disposing the material that is now reused and (ii) emissions avoided in producing and transporting raw materials that are now no longer required because of the exchange.

ISPs can therefore be leveraged to decouple economic growth from resource use and reduce the carbon intensity of production processes, whilst increasing the diversion of significant volumes of waste from landfill.

2.3 Social co-benefits

Industrial symbiosis promotes local employment. The processing of waste materials typically requires collection, sorting, cleaning and processing (the latter in particular creates jobs that are often unskilled or semi-skilled) a critical contribution to the national economy with 26.5% unemployment (Statistics South Africa, Q4 2016).

2.4 Estimated impact of industrial symbiosis in South Africa

The annual benefits achieved by WISP have been used to estimate the impact of each regional industrial symbiosis programme. The results are shown in Table 3.

The experience of WISP and the estimated impact of national activities indicate that industrial symbiosis activities can be used to drive an economic development and job creation agenda within South Africa with significant environmental benefits. It is important to note that the estimation provided would be the minimum annual benefits expected as WISP has quadrupled the tonnes of waste it diverted from landfill each year of operation.

Table 3: Potential of each regional facilitated industrial symbiosis programme based on WISP's initial impact

Key Performance Indicator		WISP (Benefits achieved over 5 years)	KISP (potential)	GISP (potential)
Relative potential impact based on GVA and waste generated		1	0.45 – 1.38	2.25 – 2.56
Waste diverted from landfill (tonnes)		10,253	4,600 – 14,100	23,100 – 26,200
Economic benefits (R million)		45.0	20.2 – 62.0	101 – 115
Fossil GHG savings	Tonnes CO_2e	64,000	28,800 – 88,300	144,000 – 163,800
	Equal to passenger vehicles taken off the road in SA	17,500	7,900 – 24,000	40,000 – 44,900
Permanent economy wide jobs created (direct, indirect and induced)		145 (of which 20 direct)	65 – 200 (of which 9 – 28 direct)	326 – 371 (of which 45 – 51 direct)

Box 1: Assumptions used to forecast impacts for national industrial symbiosis activities

Assumptions for estimation of forecast potential of regional programmes:

- *According to StatsSA's national manufacturing sector gross value add (GVA) per local municipality data of 2013* (Statistics South Africa, Q3 2014)*: Gauteng's GVA is R139 033 million, KwaZulu Natal's GVA is R75 268 million and the Western Cape's GVA is R33 886 million. Therefore, KwaZulu Natal and Gauteng can be said to have 1.38 and 2.56 times the manufacturing potential of the Western Cape*
- *According to the National Department of Environmental Affairs' National Waste Information Baseline Report of 2011 (* (Department of Environmental Affairs Republic of South Africa, 2011)*: The Western Cape, KwaZulu Natal and Gauteng produce 20%, 9% and 45% respectively of the total waste generated in South Africa. On average industrial and commercial waste accounts for 21% of the total waste stream between Cape Town and Gauteng Municipalities. Therefore, KwaZulu Natal and Gauteng can be said to have 0.45 and 2.25 times the potential of the Western Cape based on waste generation*
- *Fossil GHG savings are based on WISP's carbon calculator which has been developed by a leading South African consultancy firm for life cycle based carbon footprint estimations*
- *Permanent economy wide jobs created include direct, indirect and induced jobs. Calculated using WISP's jobs calculator based on economic multipliers developed by a leading economics consultancy using a Western Cape social accounting matrix*

2.4.1 National industrial symbiosis activities can deliver significant economy-wide benefits annually

Annualising the estimated benefits shown in Table 3 to create annual estimates, suggest that if industrial symbiosis were to operate at scale in South Africa, the minimum following impact each year:

- Divert more than 10,000 tonnes of waste from landfill[2];
- Generate more than R33 million in economic benefits (includes additional revenue, cost savings and private investment);
- Reduce fossil greenhouse gas savings by more than 47,100 tonnes of carbon dioxide equivalents (corresponding to the fossil GHG emissions of 12,900 passenger vehicles taken off the road each year in South Africa)
- Generate more than 100 economy wide jobs by returning secondary materials to the economy before losing them to waste-to-energy or landfill.

2.4.2 Funding returns from industrial symbiosis above-average compared to government benchmarks

Based on WISP's total funding to date and considering the active delivery period of April 2013 to May 2017, the following returns on invested funds have been determined:

- For every R1,00 invested by the Western Cape Government, R2.65 in economic benefits (includes additional revenue, cost savings and private investments) have been generated for the industrial symbiosis network;
- The cost to create a job through the programme is R112,900, at the less costly end of government benchmarks[3];
- The cost to divert a tonne of waste from landfill is approximately is R1780; and
- For every 63 tonnes of waste diverted from landfill, one permanent job is created in the economy.

[2] The City of Cape Town considers any waste diversion or recycling programme that diverts more than 1,000 tonnes of waste from landfill to be significant.

[3] Treasury's Jobs Fund has previously aimed for R60,000 per job (excluding the construction of new buildings) and the Industrial Development Corporation for R250,000 per job (including the construction of new buildings)

Table 4 below compares the returns on invested funds for WISP year-on-year. This analysis indicates that as funding is increased for an ISP to scale, the programme's impact and returns on funding also increase.

Table 4: Comparison of returns on government funded for WISP based on year-on-year performance

Key Performance Indicator	Year 1	Year 2	Year 3	Year 4	Trend
Annual funding (R million)	1.25	1.75	3.10	3.10	↑
Waste diverted from landfill (tonnes)	89	427	2,124	2,310	↑
Economic benefits (R million)	3.4	3.9	6.0	10.1	↑
Permanent economy wide jobs created (direct, indirect and induced)	11	17	15	40	↑
Cost per job (R)	113,640	102,941	206,667	77,500	↓
Cost to divert a tonne from landfill (R)	14,035	4,095	1,459	1,341	↓
Funding: Economic benefits (R:R)	1:2.8	1:2.2	1:1.9	1:3.3	↑

3 Industrial symbiosis creates economic opportunities in South Africa

Through facilitation and data collection, facilitated ISPs are able to deliver added benefits to government funders – identifying economic opportunities within the waste economy of a region. The ISPs are able to unlock value by identifying economies of scale by clustering resources, drive business model innovation enhancing the competitiveness of industry and catalyse the establishment of new green businesses through market-led enterprise development programmes. More recently industrial symbiosis activities have also been identified as an opportunity to catalyse the development of eco-industrial parks in South Africa.

3.1 Case study 1: Unlocking value by creating economies of scale by clustering resources

Industrial symbiosis most commonly manifests as driver to create economies of scale and cluster resources for beneficiation, thereby enabling value addition. WISP has several examples of this. Case studies for fabric and textiles, organics and plastics are provided below.

3.1.1 Fabric and textile wastes

In 2013 when WISP started working with industry, several clothing and textile manufacturers joined the industrial symbiosis network. At the time all fabric and textile offcuts and waste thread was disposed of at landfill due to a lack of alternatives in the province. Although fabric and textile waste was being recycling in Gauteng and KwaZulu Natal, the high cost of transport inhibited companies from using alterative solutions in the country.

In 2015, a fabric and textile recycler entered the Western Cape market, sorting and baling fabric and textile waste with the aim of transporting the waste to their recycling facility in KwaZulu Natal. WISP was quickly able to connect its members producing fabric and textile waste to the recycler, resulting in more than 100 tonnes of fabric and textile waste being diverted from landfill annually and approximately R550 000 in economic benefits (cost savings and additional revenue) for the companies involved.

WISP's continual engagement with the recycler may result in the company identifying large enough volumes of fabric and textile waste to consider a substantial investment in equipment and capacity in order to establish a recycling facility in the Western Cape.

3.1.2 Organic wastes

The large volume of organics disposed of at landfill presented an opportunity for solution providers to enter the market, and several solution providers are now active in the market. A suite of technologies is available including anaerobic digestors, composting and fly farming for insect protein. WISP has enabled the diversion of over 2,000 tonnes of organic waste from landfill by connecting organic waste generators to solution providers in its member network.

WISP has assisted an SME composter to increase its supply of material for composting to such an extent that it is now operating at full capacity and will have to expand its operations in order to continue growing. WISP is currently assisting the company to establish two new composting facilities so that it can provide its service to a wider market in the City of Cape Town region.

WISP has also diverted large volumes of organic waste to two biogas facilities in the Western Cape as well as the newly established fly farm.

3.1.3 Plastic wastes

Although plastic is an 'easy' material to divert from landfill as the recycling industry for most plastic types is well established, many logistics providers require large volumes to make the collection of material financially worthwhile. This results in companies stockpiling their plastic waste on site until volumes are sufficient to make transportation viable. WISP engagements with SMMEs has led to the identification of a micro logistics company serving the plastics industry and WISP is now able to facilitate the diversion of smaller quantities of plastics from landfill by directing companies to this SMME. In aggregate WISP has facilitated the diversion of 20 tonnes of plastic waste form landfill, creating financial benefits of almost R100,000.

3.2 Case study 2: Increasing competitiveness and advancing innovation

WISP has had great success diverting wood from landfill driven primarily by a single pro-active SME solution provider that recycles waste wood into pallets.

In 2013, WISP first started working with the wood pallet company. The company asked WISP to support the operation's transition from using raw timber as a raw material for wood pallet manufacturing to using broken wood pallets. The company had changed its business model from using virgin wood to manufacture pallets to recycled wood and needed to identify larger volumes of waste wood pallets in order for it to be sustainable in the long term. Working with WISP, the company was able to gain access to new wood supplies resulting in three jobs being created and R100 000 invested in new equipment in order to handle the increased wood volumes.

After working with WISP for two years and attending several Business Opportunity Workshops[4] the wood pallet company recognized an opportunity for a wood waste management company to enter the market as many different types of waste wood are disposed of at landfill and not repurposed. The company changed its business model again to become a wood waste management company. It is now an accredited waste service provider with the City of Cape Town and is able to remove all waste wood types at an industrial site and has created additional five jobs to be able to increase its processing capacity.

[4] "Quick-wins" interactive workshop where companies rapidly identify new opportunities for under-utilized resources

However, this change in business model also led to new challenges for the company to overcome, in particular to identify uses for all the wood it could not recycle into pallets. Understanding the wood market assisted the company to solve this challenge and an ecosystem of other solution providers has been created around the recycled wood pallet company. Some of the other solution providers include:

- A materials store to supply surrounding communities for suitable wood to be used as an energy source for cooking;
- A materials store established to supply high quality wood to the furniture industry.

It is important to note that with every change in business model, the wood pallet company has been able to become more competitive in its market and achieve significant financial gains. To date the company has diverted more than 600 tonnes of wood waste from landfill, generated more than R700 000 in additional revenue, created nine jobs and saved its clients more than R275 000 in waste management fees.

WISP will continue to support the company as it strives to close-the-loop and become more environmentally sustainable. The company is now investigating heat treating its pallets for export using its own wood waste as the fuel source and its potential for embedded generation using solar panels to reduce its carbon footprint.

3.3 Case study 3: Driving market-led enterprise development

In 2014, WISP was funded by Project Office of the proposed Atlantis Special Economic Zone to improve resource efficiency in the Atlantis industrial area, and to also identify opportunities for green enterprise development.

WISP documented the outward flow of underutilised resources from companies across a range of sectors, and synthesised that data into actual resource availability; identifying existing infrastructure and economic activities; and cataloguing prospective developments earmarked for the industrial area that would enable greater resource efficiency. Synthesising all the data collected, revealed market gaps or new business opportunities for entrepreneurs to capture. These are detailed in Figure 1.

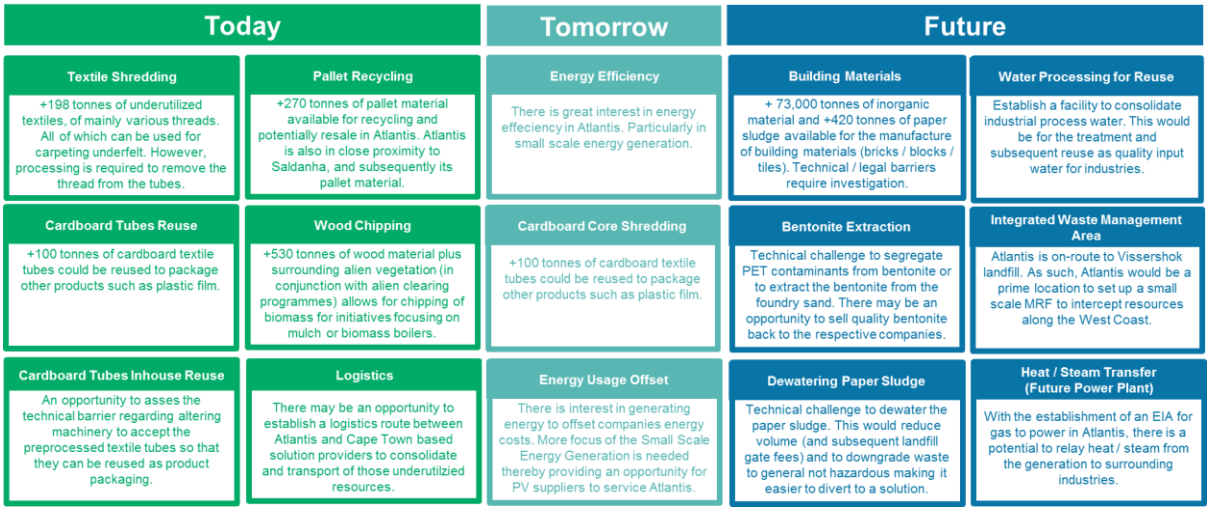

Figure 1: Summary of new business opportunities identified in Atlantis

A key challenge for WISP remained: matching the business opportunities with entrepreneurs. Therefore, in 2016, WISP partnered with the South African Renewable Energy Business Incubator (SAREBI) to run an incubation programme that would:

i. Match entrepreneurs with new business opportunities;
ii. Assist the entrepreneurs and businesses to fully develop the business concept and bring it to commercial viability; and
iii. Enhance entrepreneurial capacity and to support the business ideas through incubation, which includes operational support.

The incubation programme is currently in its final stages and WISP and SAREBI expect that at least four new green businesses will be established by end July 2017. Importantly, WISP's role is not only opportunity identification, but also linking the entrepreneurs to raw material suppliers (i.e. WISP members generating waste).

This world-first innovation of market-led enterprise development via industrial symbiosis has significantly increased the success rate of incubation – where global success rates of incubators are 1 in 1,000 for an entrepreneur establishing a viable business, WISP has increased the success rate to a comparable 57 in 1,000 (4 in 70) over a short period of three years.

As a result of the first programme's success, WISP will start a second enterprise development programme in 2017 in partnership with SAREBI focused on new market opportunities verified by WISP. WISP is also in discussion with various other agencies about how this model of market-led enterprise development might be expanded to elsewhere in the Western Cape and South Africa.

3.4 Driver for eco-industrial park development

The United Nations Industrial Development Organisation (UNIDO) (Dohel, 2017), World Bank (Kechichian & Hoon Jeong, 2016) and others aim to mainstream eco-industrial parks (see definition in Box 2) around the world through the next era of industrial development. Industrial symbiosis is widely accepted as the foundation for the development of eco-industrial parks as co-located companies pool and share resources to enhance sustainability. This may be shared waste management services, renewable energy generation, staff transportation services, but also includes industrial symbiosis resource exchanges or 'synergies' between companies.

Box 2: Eco-industrial park definition

Eco-industrial park definition: *An eco-industrial park is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resources issues including energy, water and materials. By working together, the community of businesses seeks a collective benefit that is greater than the sum of the individual benefits each company would have realized if it optimized its individual interests.* (Lowe, et al., 1995)

To date eco-industrial park activities have largely been incorporated at the planning phase of greenfield industrial zone developments or when retrofitting existing industrial zones around the world and are starting to see increasing success in terms of improved economic, social and environmental sustainability. (United Nations Industrial Development Organisation, 2016)

Over the last several years South Africa has developed a series of industrial development zones (IDZs) and is in the process of developing special economic zones (SEZs). The eco-industrial park concept has only been incorporated into one of these zones, Coega IDZ.

A new focus of the dti is revitalisation of brownfield industrial parks. The fourth phase of the Industrial Park Revitalisation Programme (IPRP) is focused on creating sustainable industrial clusters in South Africa. (Tsedu, 2017) At the same time UNIDO is running an eco-industrial park pilot programme with the NCPC-SA in Epping industrial area in Cape Town and the East London Industrial Development Zone. The outcomes of this pilot are expected to be incorporated into Phase 4 of the IPRP.

Facilitated industrial symbiosis would enhance the potential of eco-industrial park activities in South Africa by linking the park to a wider industrial symbiosis network.

4 The role of stakeholders and policy towards embedding industrial symbiosis within industry in South Africa

Industrial symbiosis activities in South Africa have demonstrated that facilitated industrial symbiosis can generate business benefits for the companies involved. More than that, the regional ISPs have the potential to identify economic opportunities that can drive economic development, job creation and enterprise development. Estimates of the impacts of national activities and the funding required, indicate that these benefits are achieved, whilst also providing returns on the funds invested.

If funding were provided to scale facilitated industrial symbiosis activities in South Africa and the regulatory framework were aligned to support the embedding of industrial symbiosis in South Africa, industrial symbiosis could be a catalyst for sustainable industrialisation in South Africa.

4.1 The importance of providing subsidised facilitated industrial symbiosis

It is critical that the delivery of facilitated industrial symbiosis is subsidised to industry so that the services of the ISPs can be provided “free at the point of delivery”. Research indicates that for innovative practices to be taken up the private sector, they need to be subsidised (Goldberg, et al., 2011). In South Africa, SMEs account for more than 70% of the ISP networks. Subsidised funding is of particular significance with reference to SMEs that do not have the same financial or human capacity compared to large corporates to be able to implement non-core activities. The importance of alignment of the institutional framework

Equally important is the role of government in creating an enabling institutional framework. It would be important for stakeholders (including regulatory bodies, policy makers, industry associations and financiers) to understand industrial symbiosis and how the ISPs can deliver both business benefits and economic outcomes.

It will also be important for industrial policy in support of industrial symbiosis be developed (refer to Section 0). It is also suggested that the development of industrial policy would need to be done in close consultation with the private sector and be careful not to favour one industrial sector over another. In this manner, the private sector is most likely to buy into new policy and implement industrial symbiosis activities. (Goldberg, et al., 2011)

4.1.1 Current legislative and policy framework

The current legislative framework broadly supports the application of industrial symbiosis in South Africa.

Table 5 below provides an overview of the relevant acts and strategies as well as their bearing on the development of industrial symbiosis programmes in the country.

Table 5: Summary of the acts and strategies that support the application of industrial symbiosis in South Africa

Act or Strategy	Overview of act or strategy	Assessment of impact on industrial symbiosis
National Environmental Management Act 107 of 1998	Sets ecological sustainable development as the framework for environmental decision making (Council for Scientific and Industrial Research, 2013)	Industrial symbiosis promotes resource efficiency and sustainable production processes.
National Environmental Management Act: Waste Act 59 of 2008	Sets the improved waste hierarchy as the basis for waste management decision making (Council for Scientific and Industrial Research, 2013)	Industrial symbiosis uses the principles of the waste hierarchy in decision making for resource exchanges.
National Waste Management Strategy (GN 344 GG 35306 of 4 May 2012)	Sets eight goals which support the implementation of the Waste Act. Included is the promotion of waste minimisation, reuse, recycling and waste recovery. (Council for Scientific and Industrial Research, 2013)	As above, industrial symbiosis uses the principles of the waste hierarchy in decision making for resource exchanges. Industrial symbiosis is one of several methods that can contribute growing the waste sector within the green economy.
South African Green Economy Accord of 17 November 2011	Sets 12 commitments to address climate change and create jobs simultaneously. Commitment 5: "Government commits to finalise a Waste Innovation Programme that aims to promote reduced waste generation during production processes. Re-use will be promoted, as one waste stream can potentially be the raw material for a separate industrial process, leading to novel products. Waste can also be a feedstock for generation of energy". (South African Department of Economic Development, 2011)	The commitment supports the implementation of industrial symbiosis as a means to reduce waste generated during production processes.
National Development Plan: Vision 2013, Chapter 5: Transition to a Low Carbon Economy of 11 November 2011	Outlines the long term strategic plan for South Africa. States that by 2030, South Africa should be resource-efficient and have reduced its dependence on carbon, natural resources and energy without compromising job creation (National Planning Commission, 2011).	Industrial symbiosis has the potential to significantly contribute towards creating a resource efficient economy, while creating jobs simultaneously.
Industrial Policy Action Plan: 2016/2017 – 2018/2019	Is the dti's specific action plan to spur industrial growth and development in South Africa. It identifies key transversal interventions that need to be implemented and supported as well as sectoral focus areas. (Department of Trade & Industry, 2016)	Industrial symbiosis is highlighted as an instrument to 'green' industry with specific reference to reducing the carbon intensity of production processes.

Industrial symbiosis is also identified as an enabler for sustainable industrial development at a provincial level, identified specifically in the Western Cape Green is Smart Strategy (Western Cape Government, 2013).

Although the legislative and policy framework for industrial symbiosis largely supports industrial symbiosis, it is important that there is alignment of the current institutional framework so that all legislative and policy instruments are reinforcing. This is of particular importance in terms of the Industrial Waste Plans and Industry Waste Management Plans that will be legislated in the future. If these plans exclude the participation of third parties, industrial symbiosis activities will be greatly inhibited.

Inter- and intra-governmental co-ordination would also be important to drive alignment across all spheres of government and continue awareness raising of industrial symbiosis activities in South Africa.

5 Conclusions

Industrial symbiosis activities in South Africa demonstrate that industrial symbiosis can be used to deliver economic, environmental and social benefits to the companies involved. The role of facilitators is particularly relevant in the South Africa context where SMEs are unlikely to have the financial, technical or human capacity to deliver non-core activities, even where these can provide substantial business benefits in the short and long term.

Further to this, the regional ISPs are able to identify economic opportunities within the waste economy of that region through the collection of data and understanding the market landscape. ISPs are able to unlock value by identifying economies of scale by clustering resources, drive business model innovation enhancing the competitiveness of industry and catalyse the establishment of new green businesses through market-led enterprise development programmes. In addition, the ISPs make a significant contribution to enhancing the competitiveness of SMEs as well as the performance of eco-industrial parks, and brownfield industrial areas in particular.

The regional ISPs demonstrate that the returns are provided on the funds invested and that these returns are in-line with government benchmarks. Therefore, if funding were provided to scale facilitated industrial symbiosis activities in South Africa, if inter and intra governmental coordination was implemented and the regulatory framework were to be aligned to support the embedding of industrial symbiosis in South Africa, industrial symbiosis could be a catalyst for sustainable industrialisation in South Africa.

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