

Washington Industrial Waste Coordination (Industrial Symbiosis)

Program Recommendations

NOVEMBER 2019

LIGHT HOUSE SOCIETY

**with International Synergies Ltd.
and Center for Sustainable
Infrastructure**

PREPARED FOR

**Washington State
Department of Commerce**



Light House is a not-for-profit working since 2006 to advance sustainability in the built environment. Our mission is to create regenerative buildings within a low carbon, circular economy. We work directly with industry to support practical yet innovative change. Light House delivers education and outreach, research, and custom professional services to advance our mission.

Cover photo: King County Wastewater Treatment Plant

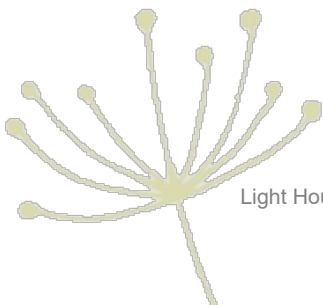


Table of Contents

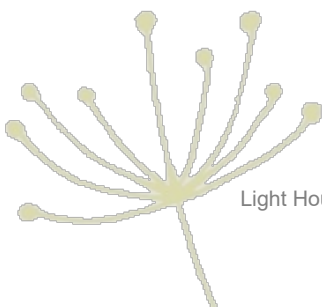
Table of Contents	i
Executive Summary	i
Key Recommendation 1: Invest in Facilitated Industrial Symbiosis	ii
Key Recommendation 2: Invest in Industrial Symbiosis RD&D	ii
Introduction	3
Project Background.....	3
Scope of Work	4
Achieving Industrial Symbiosis	5
What is Industrial Symbiosis?	5
Industrial Symbiosis Implementation Models.....	6
Industrial Symbiosis Program Case Studies.....	10
Materials Flow Database Case Studies.....	12
Washington Foundation for Industrial Symbiosis	15
Overview of Selected Washington Industrial Symbiosis Projects	15
Existing Policy Foundation	24
NISP® ‘Test-Drive’ Workshop Outcomes.....	26
Industrial Symbiosis Program Recommendations	33
1. Invest in Facilitated Industrial Symbiosis	34
2. Invest in RD&D to Support Industrial Symbiosis	41
3. Establish a Policy Framework to Support Industrial Symbiosis	44
4. Continue Support for Clean Energy Sector.....	47
5. Drive Industrial Symbiosis in Utilities and Infrastructure.....	48
6. Consolidate Data Management and Performance Reporting	51

Appendix A: International Industrial Symbiosis Case Studies

Appendix B: Canadian Industrial Symbiosis Program Feasibility Study

Appendix C: NISP® Canada Pilot Performance Report Executive Summary

Appendix D: EU Industrial Symbiosis Program Pre-Standard



Executive Summary

In acknowledgment of the global increase of industrial symbiosis and its demonstrated economic and environmental benefits, a bipartisan group of Washington State legislators sponsored SSB 5936 during the 2019 legislative session. The bill was unanimously passed by the Senate and the House Committee on Environment and Energy, but in lieu of final passage, the Washington State Department of Commerce was directed to contract for an independent examination and recommendations regarding development of an industrial waste coordination (industrial symbiosis) program.

Well-known and large complexes, like the one in Kalundborg, Denmark that has been visited by many state legislators, are tangible examples of successful industrial symbiosis. Such complexes are not created overnight, but result from successive, planned, capital-intensive projects.

Industrial symbiosis also works effectively on regional scales, engaging hundreds of businesses from multiple sectors and sizes in smaller, but no less effective, industrial symbiosis. Regional industrial symbiosis activities, especially when supported by dedicated facilitation, can result in even greater aggregate regional benefits, as demonstrated in the recent National Industrial Symbiosis Program (NISP®) pilot project in the Vancouver and Edmonton areas in Canada, the original NISP® UK efforts, and the various adaptations of the NISP® model deployed in more than 30 countries globally. This project also included a “test-drive” of the regional facilitation model, with nearly three dozen organizations from Washington state registering for a business opportunities workshop that provided training and obtained their input on industrial symbiosis.

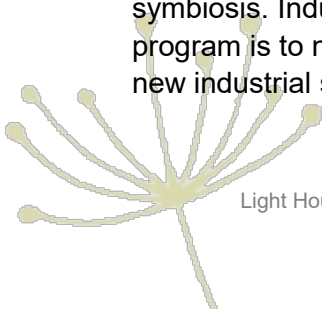
The Washington industrial symbiosis program recommendations are backed by a robust review of global case studies (collated in Appendix A), the consulting team’s personal international experience, and industry stakeholder input. The report also includes a summary of the various material data flow collection systems being used to advance industrial symbiosis. Industrial symbiosis is already emerging across the state; the goal of the proposed program is to nurture and strategically coordinate and integrate these efforts, while catalyzing new industrial symbiosis.

What do we mean by “industrial symbiosis?”

Although there is no universal definition, the recent definition presented by the European Committee for Standardization captures the key elements:

“Industrial symbiosis is the use by one company or sector of underutilised resources broadly defined (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials) from another, with the result of keeping resources in productive use for longer. It presents a systems approach to a more sustainable and integrated industrial economy that identifies business opportunities to improve resource utilisation and productivity.”

European Committee for Standardization Workshop Agreement CWA 17354: 2018 (E). December 2018.



This report presents six key recommendations for a proposed Washington program:

1. Invest in facilitated industrial symbiosis
2. Invest in industrial symbiosis RD&D
3. Develop a supportive policy framework
4. Continue to support clean energy
5. Maximize industrial symbiosis opportunities involving utilities and infrastructure
6. Coordinate and strategically manage materials flow data

The first two recommendations are the most important, representing actions that will catalyze industrial symbiosis involving businesses across sectors and sizes with relatively short-term benefits. In addition, the first two recommendations can be implemented in a way that strengthens the clean energy sector, involves utility operations and infrastructure, and creates a foundation for materials flow tracking and industrial symbiosis performance measurement. Lastly, with no “shovel-ready” large projects, implementing the first two recommendations will help to advance the existing kernels of industrial symbiosis in the state.

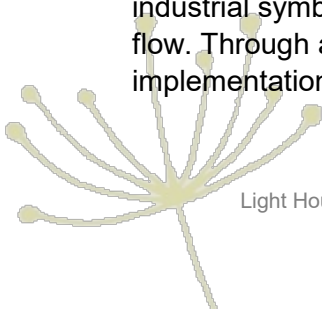
Key Recommendation 1: Invest in Facilitated Industrial Symbiosis

Facilitated industrial symbiosis can be delivered in parallel to the development of large, capital-intensive projects, such as biorefineries or integrated utility complexes. Several international evaluations found the NISP® model leads to the best outcomes of any industrial symbiosis approach (see Appendix B for a related feasibility study). A recent “test-drive” in Seattle demonstrated how facilitated industrial symbiosis can quickly increase the number of businesses engaged in industrial symbiosis. From only one matching workshop there are businesses working with NISP® Canada to pursue opportunities that could avoid 23,000 tons of greenhouse gas emissions and divert almost 95,000 tons of solid waste from landfills.

Facilitated industrial symbiosis is generally delivered regionally. For example, a program covering the state might be delivered in six regions, each with a dedicated facilitator and backed by technical and administrative support staff. Regions could enter the program at once or on a rolling basis. Based on global experience, local government agencies and utilities could be co-investors. The NISP® Canada pilot engaged more than 350 businesses, generated around \$6 million in economic benefit, and diverted more than 250,000 tons of waste from landfill in 20 months. The longest running facilitated industrial symbiosis program (Northern Ireland) has been running for 13 years, and was just funded for another five years.

Key Recommendation 2: Invest in Industrial Symbiosis RD&D

The report outlines several ways in which the state could support industrial symbiosis RD&D. The easiest way would be to fund a competitive industrial symbiosis grant program. The Circulate Industrial Ecology (Australia) grant program is a great example (see Appendix A). Grants could support emerging large projects, new opportunities that spinoff from facilitated industrial symbiosis, and/or research around product development using a specific waste flow. Through a competitive process, the state can ensure that objectives, such as time to implementation and scale of economic or environmental benefits, are met.



Introduction

Project Background

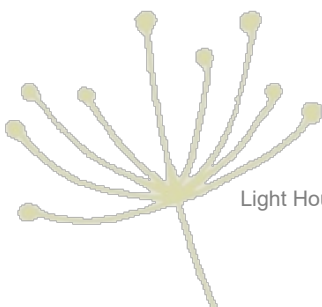
During fall 2015 and 2017, Seattle-based consulting group i-Sustain, with support from the Olympia-based Center for Sustainable Infrastructure (CSI), brought bipartisan groups of Washington legislators and other community leaders to Denmark and Sweden. Funded by the Scan Design Foundation, the goal was to create common ground and spark excitement for clean manufacturing and production in Washington state, and to create a platform for bipartisan collaboration for smart, sustainable infrastructure policies.

This trip included an inspiring visit to Kalundborg, Denmark, a pioneering example of industrial symbiosis. After visiting Denmark, these legislators coalesced around some shared infrastructure innovation goals, and targeted industrial symbiosis for their first collaborative push in the policy arena. The group recognized that clean manufacturing and production can grow jobs and industry across Washington state – east and west, and in rural, suburban and urban communities – while also extracting maximum value from resources and reducing waste and pollution.

CSI continued working with state officials to build momentum around industrial symbiosis. The bipartisan participants in the Scandinavian study tours introduced a bill to take the first step toward making Washington a national leader in clean manufacturing and production. Their bill (SSB 5936), which directed the Department of Commerce (“Commerce”) to produce a proposal and recommendations for setting up an industrial waste coordination (IWC) program by December 1, 2019, was unanimously passed by the Senate and the House Committee on Environment and Energy.

While there was not enough time for additional consideration by the House, interest in and the commitment to making Washington a national leader in clean manufacturing and production continues to grow. In the 2019-2020 biennial budget, Commerce was provided \$100,000 to contract for an independent assessment and associated recommendations for establishing an industrial waste coordination program. On August 5, 2019, Commerce issued a Request for Proposal (RFP) for an Industrial Waste Coordination Program assessment to be delivered to the Legislature by December 2019.

A third bipartisan study-group visited Denmark in September 2019. Participants are interested in continuing to explore smarter sustainable infrastructure and industrial symbiosis policies.



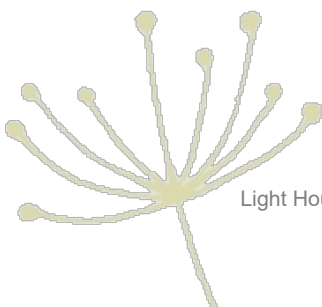
Scope of Work

Commerce requested a report providing recommendations related to a potential IWC (Industrial Symbiosis) Program. More specifically, the report should:

- Better define and increase the understanding of industrial symbiosis, including providing examples of existing, relevant programs.
- Present at least six case studies with enough depth and breadth to demonstrate IWC program options and their impact on an array of sectors in Washington.
- Reflect industry stakeholder input, gained through convening one or more stakeholder meetings.
- Evaluate existing material flow data collection systems and provide recommendations for their use in Washington for identifying industrial symbiosis opportunities.
- Synthesize the above work into a final report that also presents recommendations for an IWC Program, including economic and environmental performance metrics, organizational structure, priorities and costs, policy foundation, and a roadmap.

The project was awarded to a team led by Light House Sustainable Building Centre Society (“Light House”) of Vancouver, British Columbia and including CSI and the UK-based International Synergies Ltd. The selected approach included the above scope of work plus added value in the form of a test-drive of the National Industrial Symbiosis Program (NISP®) model, now adapted to 35 countries worldwide. After a feasibility study covering much of the same ground as requested by Commerce, Light House concluded that NISP® is the best model for quickly delivering the most industrial symbiosis. That feasibility study is attached to this report as Appendix B. This conclusion was reinforced by Light House’s successful NISP® pilot in Canada, in both the Metro Vancouver region and the Greater Edmonton area of Alberta. The pilot performance report executive summary is attached as Appendix C.

The NISP® test-drive in Washington state also engaged a diverse set of stakeholders and sought input into potential industrial symbiosis program needs.



Achieving Industrial Symbiosis

What is Industrial Symbiosis?

In Washington state, “industrial waste” is defined as “...any liquid, gaseous, radioactive or solid waste substance or combinations thereof resulting from any process of industry, manufacture, trade or business, or from the development or recovery of any natural resources.” *RCW 82.34.010*

Although referring to “industrial waste”, the definition is broad enough to encompass all outputs from commercial or industrial operations. This is important because globally, industrial symbiosis is practiced by businesses across all sectors and sizes. For the purposes of this report, we also consider that industrial symbiosis can use all wastes, including those resulting from energy, water, wastewater, and solid waste management utilities and from government operations, ranging from road construction to parks and resource management.

Industrial symbiosis first emerged as a means of reducing industrial waste, but has evolved to include other elements. Three recent and widely accepted definitions are presented below. As most policy frameworks driving industrial symbiosis include a definition of industrial symbiosis, these definitions could be referenced or adapted to future state legislation.

“Industrial symbiosis engages different organisations in a network to foster eco-innovation and long-term culture change. It provides mutually profitable transactions for novel sourcing of required inputs, value-added destinations for non-product outputs, and improved business and technical processes.”

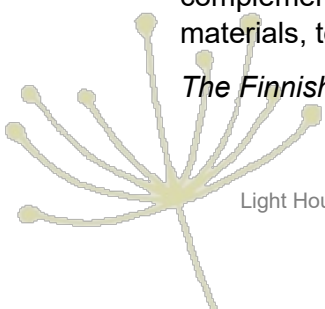
Lombardi, R. and Laybourn L., Redefining Industrial Symbiosis: Crossing Academic–Practitioner Boundaries, Journal of Industrial Ecology, Vol 16-1, Pg. 28-37, February 2012

“Industrial symbiosis is the use by one company or sector of underutilised resources broadly defined (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials) from another, with the result of keeping resources in productive use for longer. It presents a systems approach to a more sustainable and integrated industrial economy that identifies business opportunities to improve resource utilisation and productivity.”

Industrial Symbiosis: Core Elements and Implementation Approaches, European Committee for Standardization (CEN) Workshop Agreement CWA 17354:2018 (E), December 2018

“Industrial symbiosis is an industrial ecosystem where unused or residual resources of one company are used by another. This results in mutual economic, social and environmental benefits. It is a process involving several companies – firms that complement one another provide mutual added value through efficient use of raw materials, technology, services and energy.”

The Finnish Innovation Fund Sitra, 2019



The common theme is that industrial symbiosis results in the greatest value being extracted from resources – material, water, and energy, as well as from physical assets such as buildings, equipment and infrastructure and even from human resources in the form of capacity and expertise. Industrial symbiosis adds value by supporting the collaborative flow or sharing of these resources among businesses and other organizations, ultimately resulting in circular resource flows rather than linear take-make-use-dispose resource flows.

Industrial Symbiosis Implementation Models

The CEN¹-CWA 17354 *Industrial Symbiosis: Core Elements and Implementation Approaches* defines four approaches to achieving industrial symbiosis. These four approaches generally align with our collective experience. **Any industrial symbiosis program can incorporate one or more of these elements; in some cases, the deployment of one element can help to reinforce the outcomes of another element.**

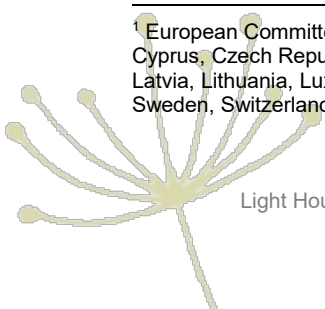
Self-Organized Industrial Symbiosis

Self-organised: a bottom-up approach resulting from direct interaction among industrial actors, without external coordination. Expertise resides within the organisations with resources and opportunities; organisations identify, assess and advance opportunities themselves. *CEN-CWA 17354 Industrial Symbiosis: Core Elements and Implementation Approaches*

Self-organized systems tend to involve fewer partners (a handful of companies involved versus dozens). However, large resource flows may still be involved if one or more of the actors are large-scale industries, such as pulp mills or petroleum refineries. Industrial symbiosis in these systems is usually funded by the companies involved, although sometimes government incentives provide additional support. Kalundborg, Denmark (see case study) evolved as a self-organized system, driven initially by several large industrial operations. Some hypothetical examples of self-organized industrial symbiosis are presented below:

- Company A is facing challenges with a waste stream (disposal cost, environmental risk, public concerns, production costs, etc.).
 - Working with a local research institution and/or its own internal research team, it develops a list of products that use similar materials for its inputs. Company A discovers a similar company three miles away. Working through various R&D steps and business negotiations, Company B tweaks its production to be able to accept the waste from Company A, and an individual industrial symbiosis program is achieved.
 - Working with a local research institution they develop a new product. The research institution, Company A, and local eco-investors form a joint venture to establish a new Company B, which will transform Company A's waste into the new product.

¹ European Committee for Standardization members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



- Company A already successfully converts a waste resource to a product. It has capacity to expand its production. It retains a consultant to develop a regional materials inventory to help identify other waste streams it could use. Company A reaches out to the top three potential new suppliers, and secures contracts to buy waste streams from two of them.

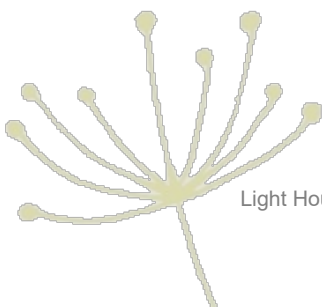
Facilitated Industrial Symbiosis

Facilitated: wherein a third-party intermediary coordinates the activity, working with organisations to identify opportunities and help bring them to fruition. Facilitators (sometimes referred to as practitioners) work with the companies to identify, assess and advance opportunities; often the onus is on the facilitators to advance opportunities. Facilitator business models vary from commercial brokers to public investment networks and any combination thereof. *CEN-CWA 17354 Industrial Symbiosis: Core Elements and Implementation Approaches*

Facilitated industrial symbiosis generates more industrial symbiosis opportunities and engages more actors than self-organized systems. Generally, facilitated industrial symbiosis also results in greater implementation and higher environmental and economic outcomes. Industrial symbiosis facilitators can help overcome barriers associated with a need for the extra-departmental and cross-sector work required to implement most industrial symbiosis opportunities. In addition, facilitated industrial symbiosis increases the participation of small and medium enterprises in industrial symbiosis.

Examples of facilitated industrial symbiosis efforts are presented below:

- A government permitting-officer has access to solid waste and wastewater generation data. Working with her economic development colleagues, she identifies several potential industrial symbiosis opportunities. She convenes meetings for the potential industrial symbiosis partners, helps match them with local researchers where required, and keeps the projects front and center in the businesses' minds until they are implemented.
- A regional industrial symbiosis facilitator brings together dozens of regional businesses, government operations managers, government regulators, and the RD&D community to identify dozens of potential industrial symbiosis opportunities. While each attendee receives a report and contact information for the other parties with whom they can establish industrial symbiosis, after two months, only four companies have contacted each other. The regional facilitator follows up continuously, helping businesses implement industrial symbiosis, providing practical assistance such as collecting samples from Company A and bringing them to Companies B and C for testing. Over a year, the regional facilitator has engaged more than 100 businesses and has shepherded several industrial symbiosis opportunities to completion.



Information and Communications Technology or Data-Driven

ICT-supported: industrial symbiosis activity is supported by an ICT (Information and Communications Technologies) system to capture and manage data on resource availability and potential synergies. The onus lies with the software users, be they companies, other organisations or facilitators. *CEN-CWA 17354 Industrial Symbiosis: Core Elements and Implementation Approaches*

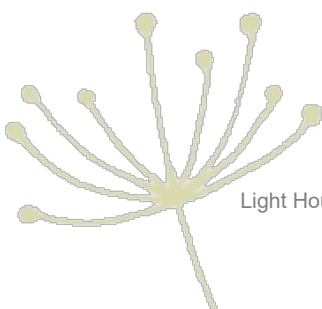
For many years, ICT or data driven approaches were believed to be the main method for achieving industrial symbiosis. Waste exchange databases are the main example of this, but we would also include models underpinned by waste audits and computer modelling in this category. The idea is intuitive – if a company has data about its waste, it will automatically seek to add value to that waste stream. Conversely, if a company might save money by switching to a non-virgin input, it will automatically seek that information. Both companies will simply enter their data into a waste exchange database (or provide it to a waste auditor) and symbiosis will happen.

In the ‘early days’, such data-driven approaches were the main means by which people were pursuing industrial symbiosis. In the late 1990s, as Ms. Casavant studied industrial ecology in graduate school, she recalls testing the US EPA-developed Facilitating Symbiosis Tool (“FaST”), a waste exchange platform in which users inputted their waste materials and then the platform provided a specific or generic match for the material. The algorithm was clunky, matching materials such as waste aluminum cans to aluminum bicarbonate manufacturers, a clear mismatch from a chemistry standpoint. The FaST program has long since disappeared, its effectiveness hampered technically but also because, as with other waste exchanges, implementation of matches is generally limited without facilitated assistance.

Also, during the late 1990s, Ms. Casavant’s graduate research involved the completion of material and energy audits of six companies, and then the input of this information into simulation software that allowed for the testing of potential symbiotic linkages. Some of the potential industrial symbiosis among these businesses had a clear business case, but, even under a common parent company, there was no implementation.

Over the years, waste exchange databases have developed better interfaces, mobile usability, and, recently, are incorporating artificial intelligence, increasing their ability to identify industrial symbiosis. Implementation of this industrial symbiosis, though, is limited.

To be clear, waste exchange databases do generate industrial symbiosis, but overall environmental outcomes tend to be smaller (and the number of businesses involved tend to be fewer) than facilitated industrial symbiosis, as is later demonstrated in the case studies. **Currently successful waste exchanges also generally include facilitation services to support implementation. Facilitators comb the data looking for matches and can work with businesses to help implement the matches.** Facilitated industrial symbiosis and ICT-driven industrial symbiosis can be quite complementary.



Strategic or Planned

Strategic or planned: a top-down approach where networks are formed following a central plan or vision that includes attracting new businesses to regeneration sites or purpose-built developments. The onus lies with the central body (often public sector) implementing the plan or vision. *CEN-CWA 17354 Industrial Symbiosis: Core Elements and Implementation Approaches*

Strategic or planned industrial symbiosis has proven the hardest to achieve, especially in democratic, market economies. Strategic or planned industrial symbiosis usually involves the development of a new eco-industrial park or the attraction of businesses based primarily on their ability to immediately participate in industrial symbiosis.

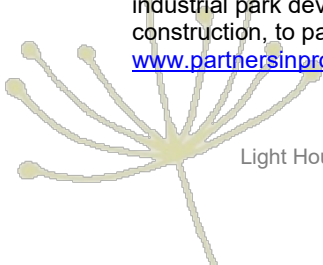
In the eco-industrial park approach, the developer is able to wait for the “right” businesses to locate in the development. North American capital (and North American taxpayers) are generally not so patient. This, combined with greatly different energy price incentives, is also why there are still fewer bioenergy, district heating and cooling, and similar systems built and operating in North America than in Europe. However, it should be noted that eco-industrial parks are still able to demonstrate innovation in site, infrastructure, and building design. For example, the Port of Portland’s Gresham Vista Business Park, an eco-industrial park pilot project, incorporated innovative ecological storm water management and greatly advanced industrial green building in Oregon. There was no industrial symbiosis established at “start-up”, and the Port was not in a legal or financial position to wait to sell land only to businesses with immediate industrial symbiosis flows.^{2,3}

The business attraction approach has been coined Regional Economic Development via Intelligence-Based Industrial Symbiosis or REDIBIS by ISL-UK. As part of a REDIBIS study for the Tyseley Environmental Enterprise Zone (TEEZ) in Birmingham, UK, ISL-UK analyzed resource flows from the regional NISP® program plus other public waste data. SYNERGie® was used to identify potential symbiosis matches, but focused on a distance of 10 kilometers from TEEZ rather than within the larger region. The potential matches were then ground-truthed in workshops with businesses in Tyseley, which generated additional matches (facilitated industrial symbiosis augmenting the base ICT-derived matches). Two strategic sectors for cluster-based business attraction were identified.

Implementation now includes a 16-acre sub-district called the Tyseley Energy Park on land owned by one of Birmingham’s oldest manufacturers. There is a new \$64 million U.S. Biomass Power Station partly funded by the government-backed green investment bank. There is also a planned zero carbon refuelling station (hydrogen, compressed natural gas, biodiesel, and rapid electric chargers). The Birmingham City Council is piloting hydrogen-

² For further details refer to the *Gresham Vista Business Park Lessons Learned* report, prepared by Light House: www.oregonmetro.gov/sites/default/files/2017/02/27/Gresham-Vista-Business-Park-Eco-Industrial-Lessons-Learned.pdf

³ For an additional resource, please refer to the detailed guide to developing eco-business zones (eco-industrial parks) prepared by Light House for the Toronto and Region Conservation Authority. The guide covers eco-industrial park development, from master planning, to subdivision, to infrastructure and utility design and construction, to parcel, lot and building design and construction. The guide may be downloaded here: www.partnersinprojectgreen.com/resources/guide-to-eco-business-zone-planning-development



fuelled buses, which would use the fueling station. The Greater Birmingham & Solihull Local Enterprise Partnership (GBSLEP) covered one-third of the cost for the access road to the Tyseley Energy Park.

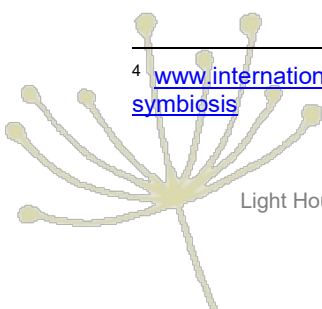
It is possible that a utility company evolving into an integrated utility complex might be considered strategic or planned industrial symbiosis, but we believe this is better seen as self-organized industrial symbiosis. As other means of achieving industrial symbiosis, strategic or planned industrial symbiosis has seen greater success when merged with Facilitation and ICT models, as in Basildon, UK⁴, or WISP in South Africa, which applied the concept to Sacks Circle and Atlantis areas in Western Cape. Sometimes, a top-down approach begins with the development of an eco-industrial plan or strategy, or a Regional Economic Development via Intelligence-Based Industrial Symbiosis (REDIBIS) strategy, often developed with the aid of ICTs. Then, the lead agency realizes facilitation is required to implement its ideas, which usually require that other stakeholders besides itself take action.

Industrial Symbiosis Program Case Studies

Based on research of publicly available documents and on our collective experience, including CSI's participation in three study tours in Denmark, International Synergies Ltd.'s experience in 35 countries and advisory role to the EU, and Light House's experience in delivering the NISP® Canada pilot and decades of eco-industrial park work, we compiled case studies based on the following projects:

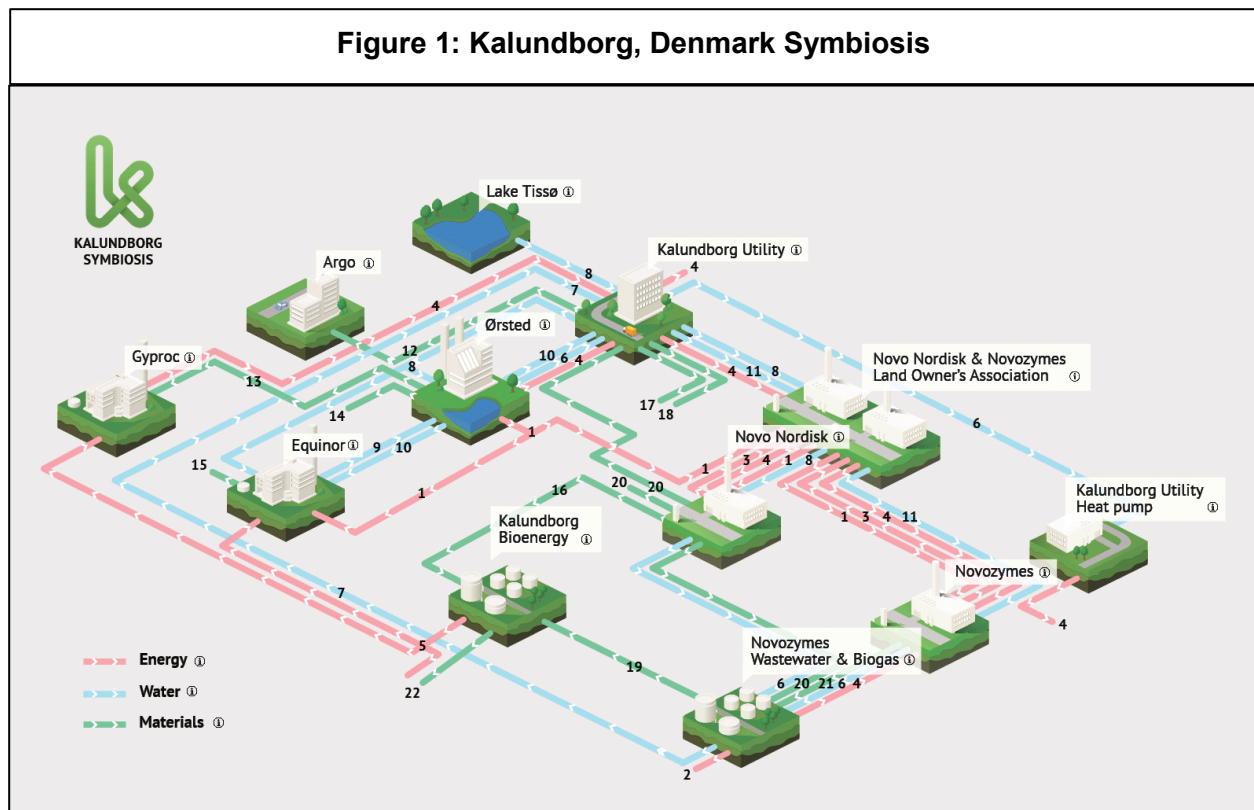
- Kalundborg, Denmark (self-organized)
- Billund Bio-refinery, Denmark (self-organized)
- Fors A/S Biogas Plant, Denmark (self-organized, with limited facilitation component)
- Metro Vancouver Integrated Resource Recovery, Canada (self-organized)
- National Industrial Symbiosis Programme (NISP®) UK (facilitated with ICT support)
- NISP® Canada (facilitated with ICT support)
- Circulate Industrial Ecology Program, New South Wales, Australia (self-organized)
- The (Invest NI) Industrial Symbiosis Service, Northern Ireland, (facilitated with ICT support)
- Southern Waste Information Exchange, Florida (ICT with limited facilitation component)

⁴ www.international-synergies.com/projects/transformation-of-burnt-mills-eco-industrial-park-through-industrial-symbiosis

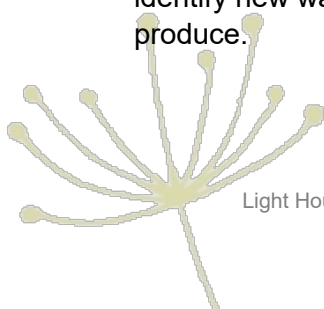


Large-scale industrial symbiosis complexes offer tangible examples of industrial symbiosis. These projects are generally capital-intensive, take many years to reach fruition, and often include (or solely comprise) utility and bioenergy or biorefinery operations. These operations often incorporate aggregated waste streams such as municipal wastewater or solid waste, or accepting significant industrial waste streams from one or more supplier, such as manure from local dairies. Due to their scale, resource flows and associated solid waste diversion and greenhouse gas emission reduction are generally large. The existence of utilities with an ability to integrate water, wastewater, energy, and solid waste services under one (generally public and non-profit) corporate umbrella is helpful. Local district heating and cooling facilities often drive the business case for these projects.

Figure 1: Kalundborg, Denmark Symbiosis



Programs with a heavy facilitation component succeed in capturing significant regional waste material flows for industrial symbiosis, especially from the private sector. The reported economic and environmental benefits from facilitated programs can meet or exceed those of large-scale industrial symbiosis. These facilitated industrial symbiosis programs generally require operational funding from government sources, but not to the level of RD&D and capital required for utility and biorefinery operations. Facilitated symbiosis can feed RD&D by engaging regional institutions in applied research related to unique, regional private waste material flows uncovered by facilitated industrial symbiosis. Utility operations and bioenergy or biorefinery operations are frequent participants in facilitated programs, which help them identify new waste streams they can take in and new destinations for the waste streams they produce.



Waste exchanges have been used for decades to advance industrial symbiosis. We completed a preliminary review of waste exchanges, including the Materials Marketplace programs, but the reported solid waste diversion numbers were relatively low (approximately 840 tons per year for Ohio Materials Marketplace, approximately 390 tons per year for Tennessee Materials Marketplace, and approximately 100 tons per year for Austin Materials Marketplace). The exception is the Florida-based Southern Waste Information Exchange (around 69,000 tons per year), although these numbers may include conventional recycling. This is consistent with international findings – uptake with waste exchanges tends to be low, as does implementation, with exchanges relying on businesses to find each other and build a personal and commercial relationship, especially for symbiosis versus exchanges that simply help connect a business to a waste hauler. We have included the Southern Waste Information Exchange case study in Appendix A.

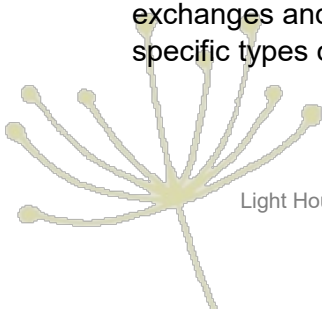
Lastly, an RD&D push for industrial symbiosis and pull from industrial symbiosis efforts can be seen in most of the case studies present. Often, this is supported by government granting programs tangential to industrial symbiosis, e.g., for waste-to-energy capital costs. However, one state in Australia runs the Circulate Industrial Ecology Program for RD&D, specifically providing grants for industrial symbiosis projects.

The case studies demonstrate the power of facilitated industrial symbiosis, especially as deployed through the NISP® model, in engaging multiple sectors in industrial symbiosis, with aggregate benefits on the scale of the large, self-organized industrial symbiosis complexes. The benefits of facilitated programs can be seen after one or two years of effort, while the industrial symbiosis complexes take longer to accrue. However, each of these models results in significant benefit. Ideally, any industrial symbiosis program should incorporate both models, especially since facilitation can increase opportunities for the large complexes. RD&D support can help overcome region or business-specific barriers for industrial symbiosis. Waste exchanges are not recommended; ICT platforms should be used instead to support facilitation, and to integrate the materials flow information and performance monitoring from facilitation efforts and industrial symbiosis complexes.

Materials Flow Database Case Studies

Intuitively, the collection and analysis of data regarding businesses' wastes should result in greater industrial symbiosis. Even before the term "industrial symbiosis" reached the mainstream in the late 1980s and early 1990s, the collection of waste data was seen as essential for advancing waste re-use and recycling. The 1970s saw the first uses of ICT as waste exchanges were established to support industrial waste reuse.

The use of ICT specifically for industrial symbiosis dates back to the 1990s, when the Matchmaker! System and U.S. EPA's Facilitating Applied Symbiosis Tool (FaST) were developed to identify local synergy opportunities based on public data. As ICT platforms evolved, the number of ICT web-based waste exchanges has grown and functionality has increased. Nevertheless, there has been relatively poor user uptake of ICT for waste exchanges and industrial symbiosis since these systems continued to fail to account for the specific types of information needed by *and the capacity of* industrial users.



Any ICT tool designed to advance industrial symbiosis should have the following functionality:

- **Flexible data entry** means from multiple data sources. Data entry can be direct only, or a mix of direct entry with bulk upload of publicly available data or other datasets (e.g., waste inventories, business license databases, discharge permits).
- **Accept company and resource data:** ICT tools will be most useful if they collect information regarding company site, contact, resources, and matches between resources.
- **Calculate performance metrics and support performance reporting:** One of the biggest challenges in comparing the performance of ICT tools or ICT-focused industrial symbiosis programs is a lack of analytical reporting. Even when personal interviews are conducted, program operators can rarely provide usable outcome data.
- **Be user friendly:** Besides ease of navigation, industrial symbiosis ICT platforms that require users to have a high degree of technical knowledge about their resources and/or knowledge necessary to search for potential match options can put users off and lead to systems becoming rarely used or abandoned altogether.
- **Operate at multiple scales:** The size of coverage of existing platforms can vary from local (aimed at single industry parks) to regional to national to international. Ideally, an industrial symbiosis ICT tool should be able to accommodate and move between levels. Generally, though, the greater the coverage, the greater the options available to a user and the greater the number of potential matches.
- **Be active versus passive:** The majority of systems are passive. That is, the user has to drive all aspects of the system (e.g., data entry, searching for opportunities). This often means the user's experience of the system is limited by the ability of the user – how much data they can enter and what they know to look for. An active system offers options beyond the user's knowledge or experience. Active support can range from data entry support to the use of algorithms or artificial intelligence offering match suggestions. Of course, good quality data needs to be input for an active system to be successful.

The EU has funded several projects to develop new industrial symbiosis tools. A review of these platforms, as well as the few available North American tools supporting waste coordination, can be found in Appendix A.

None of the EU-funded tools are well-utilized beyond the conclusion of general three to five-year project timelines, or commercialized beyond their pilot regions. This is consistent with the findings of the competitive process just closed by the EU, which selected SYNERGie® as its cross-country platform to support industrial symbiosis programs and performance monitoring and reporting. In addition, setting aside the fact that material exchange databases have not proven as effective as facilitated programs in fostering industrial symbiosis, none of the straight material exchange databases are suitable as government-level monitoring reporting tools.

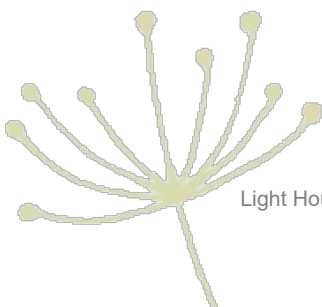
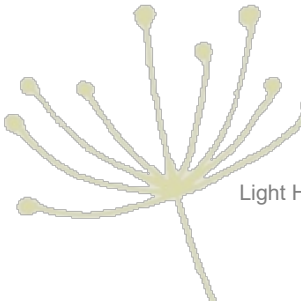


Table 1: Overview of Materials Database Tools

System	Data source		Data included		Matching process					Deployed in?	Facilitation support? (beyond any automated matching)	
	User entry	"Big" data	Site/contact	Resource	GIS	User (passive) match ID	Automatic (active) match ID	Progress tracked (incl. barriers)	Outcomes Tracked			Reporting Features
Acif	✓		✓	✓	✓	✓		?	?		France	No
ASPIRE	✓	?	✓	✓		✓	Supply chain option model	?			1 region, Australia	Limited - 4 hrs per week per community
Bizbiz Share	✓	X	✓	✓	✓	✓	✓	✓	X	?	Quebec	Limited - paid by business
By product exchange platform	✓		✓	✓		✓					Spain	41 resources
e-simbioza*	✓		✓	✓		✓		?	?		Slovenia	No
Excess Materials Exchange	✓	X	?	✓	?	✓	✓	?	X	?	Amsterdam	No
iHK-recyclingbörse*	✓		✓	✓		✓		?	?		Germany	No
iNex	✓	✓	✓	✓	✓	✓	✓				France	Companies get a report.
Life m3p	✓		✓	✓		✓	✓	?	pending		4 EU countries	Limited, mainly connection to product design
LoopLocal	✓	✓			✓		✓				Sweden	Proof of concept only, assisting to find where to place a program
US Materials Marketplace	✓	?	✓	✓	✓	✓	?	✓	✓	?	USA/Turkey	Limited, dependent on host agency
MOVECO	✓		✓	✓	?	✓		?	?		Germany	
SHAREBOX	✓		✓	✓	✓	✓	✓	✓	✓		Multiple EU	Custom application of SYNERGie, but limited facilitation
SymbioSyS	✓		✓	✓	✓	✓	✓				Spain, Mexico	Small pilot appears to include business follow-up
SYNERGie	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	used in 25 countries	Designed to complement facilitation. Platform tracks facilitation efforts.

*Smile Resource Exchange (Ireland), ZeroWIN's Resource Exchange Platform (EU), Waste is Not Waste (waste exchange, Singapore) were removed as the programs have ceased operation. MAESTRI proposed developing an IS tool, but ended up developing a toolkit (e.g., case studies).



Washington Foundation for Industrial Symbiosis

Although the term “industrial symbiosis” did not emerge until the late 1980s, the practice of transforming a waste into a product goes back centuries. It is reasonable to expect, then, that there are already examples of industrial symbiosis happening in Washington state. Indeed, this is the case.

The key for a future industrial symbiosis program is to leverage these efforts so that industrial symbiosis grows systematically and strategically, accruing even greater economic and environmental benefits for both the private and public sectors.

Although a full inventory of existing efforts was outside the scope of this study, selected examples of industrial symbiosis already underway in the state are presented in the next section. Examples of existing policy that might be linked to industrial symbiosis efforts are also presented. Lastly, the outcomes of the NISP® “test-drive”, which engaged businesses in a small-scale facilitated industrial symbiosis activity, are also described.

Overview of Selected Washington Industrial Symbiosis Projects

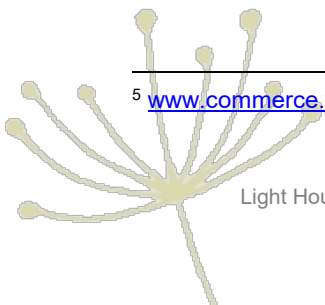
Renewable Natural Gas Roadmap for Washington State

Renewable Natural Gas (RNG) production intrinsically involves bio-based industrial symbiosis. This is especially true since the utilization of “waste” feedstocks from the agriculture and agriculture value chain can improve the RNG business case. RNG production is also frequently an element of integrated utility symbiosis clusters. Washington has enacted several policies to support RNG production, and a number of academic, private, and utility players are also helping to increase RNG production. These efforts will only increase industrial symbiosis activity as demonstrated by most RNG production, and will also likely help to tease out waste bio-based resources that could be aggregated for other industrial symbiosis as well, such as nutraceuticals.

However, as discussed in the recent report, *Promoting Renewable Natural Gas in Washington State: A Report to the Washington State Legislature*⁵, prepared by the WSU Energy Program and Department of Commerce in December 2018, the growth of RNG will require tens of millions of dollars of capital investment, with public waste management utilities best positioned to deploy projects in the near-term. So, while RNG projects could be part of tangible industrial symbiosis, it will be several years before new projects come online.

The report notes there are already three large biogas projects producing RNG equivalent to 1.3% of current natural gas consumption in the state. Although the authors found hundreds of potential biogas sources in the state, total project development costs will likely be \$20 to \$30 per MMBtu. This corresponds to reported total capital investment in the existing three pipeline-intertied RNG projects of between \$80 million and \$100 million. Other data shows WWTP-derived RNG in Washington and Oregon will likely require investments of between \$9

⁵ www.commerce.wa.gov/wp-content/uploads/2019/01/Energy-Promoting-RNG-in-Washington-State.pdf



million and \$12 million per project, while new dairy digester-based systems will likely cost \$7.5 million to \$18 million per project.

The report includes an inventory of potential biogas feedstocks and sources, including landfills, wastewater treatment plants, livestock production, source-separated organics (residential and industrial), food and beverage processing, and other sources like fish hatcheries, orchards, and vineyards. Little data was available for food processors' waste production; gross sales and employment levels were used as proxies for potential high-volume waste production.

The report identifies many near-term (less than five-year) opportunities for RNG production from 15 waste management facilities, 27 dairies, and organic municipal solid waste, especially in the King, Snohomish and Pierce counties.

Integrated Wastewater Utility Services (King County)

The King County Wastewater Treatment Division is practicing industrial symbiosis, transforming biosolids into fertilizer and generating and utilizing biogas from its wastewater treatment plants. Its extension from a straight WWTP to a WWTP that generates useable biogas and biosolids provides a foundation for further integration and expansion as demonstrated in several of the Danish case studies.

The King County Wastewater Treatment Division "...models leadership in sustainable development every day. We turn biogas from the wastewater treatment process into clean energy. We clean and recycle wastewater solids (poop and food) into a nutrient-rich soil builder for plants. We incorporate green building practices into construction projects. Our grant program helps communities improve water quality and promotes equity and social justice."⁶

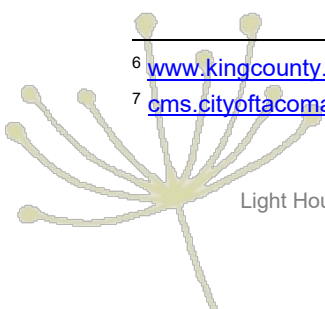
It should be noted that the City of Tacoma is also expanding its use of existing biogas to a fuller RNG generation system.⁷

Clean Manufacturing Innovation Park (Spokane)

In Spokane, the West Plains Public Development Authority, in partnership with the city, county, and airport, is taking steps to develop a Clean Manufacturing Innovation Park. The goal is to make the area a magnet for leading edge companies in advanced materials manufacturing, transport, and clean technology. After Spokane-area leaders participated in a sustainability innovation tour of Scandinavia in September 2018, and learned about Kalundborg, Denmark's world-class "Industrial Symbiosis" clean manufacturing park, they recognized the important business and economic development opportunities that Spokane could realize by embracing a similar model. The Clean Manufacturing Innovation Park will expand on the industrial symbiosis demonstrated by the nearby Spokane Waste to Energy Plant and the city's Materials Recovery Facility.

⁶ www.kingcounty.gov/depts/dnrp/wtd/sustainability.aspx

⁷ cms.cityoftacoma.org/enviro/sustain/Organics_to_Energy_12_5_2017.pdf



“For example, some waste flowing into the Spokane Waste to Energy plant could be used to create renewable biogas to power the city’s garbage trucks, which carry the materials to the Waste to Energy and recycling plants to be processed. The materials produced by the recycling plant, such as glass and plastic, could be used as input material in the manufacturing of products.”⁸

Spokane’s vision for its Clean Manufacturing Innovation Park offers a powerful, unifying frame upon which to build an industrial ecosystem of innovation that can attract growing hubs of businesses – in advanced materials and manufacturing, transport, and clean tech, along with associated suppliers, start-ups, and research institutions. These companies will be attracted not only to clean-and-green brand value, but also to cost savings from district-scale industrial symbiosis infrastructure, and the business benefits of close proximity to a growing industry cluster rich in R&D, technology, and workforce linkages.

The city’s industrial symbiosis vision also encompasses wastewater, food waste, biosolids and other organic waste streams that can be converted to RNG, biochar, and other valuable energy and soil amendment products.

LOTT Cogeneration System (Olympia)

LOTT stands for the Lacey, Olympia, Tumwater and Thurston County wastewater alliance. Recognizing that the regional WWTP was generating methane, the alliance pursued a co-generation system to capture the methane for energy generation. The permit process required to achieve this has been well documented and serves as a useful roadmap for similar projects in the future.⁹

The original Budd Inlet Treatment Plant has been in operation since the 1950s and is located on a 14-acre site in downtown Olympia. An initial co-gen system ran from 1984 to 1999. The co-gen system installed in 2009 captures excess heat from power generation for a small district heating system serving LOTT and the neighboring Hands-On Children’s Museum. The upgraded co-gen system also supplies electricity to those buildings, as well as to LOTT’s Education Center and Water Quality Lab. The system produces about 10% of the annual electricity needs of these facilities, saving LOTT \$120,000 per year.

In the early stages of the upgrade, LOTT needed to develop a compelling business case for Puget Sound Energy, which provided a grant to cover 70% of the costs of the engineering studies needed to develop the business case. Then, a design/build process with Trane was used to execute the project. A description of the permits required is available online.

Wind River Biomass Utility (Skamania County)

Wind River Biomass Utility (WRBU) is working to establish a biomass utility in the Columbia Gorge area of Skamania County near Carson and Stevenson. They intend to convert forestry waste products into energy and have plans for several other associated processes and synergies. WRBU buys wood waste, creating a new revenue stream for forestry firms, especially smaller private timberland owners. The wood waste is then processed to produce

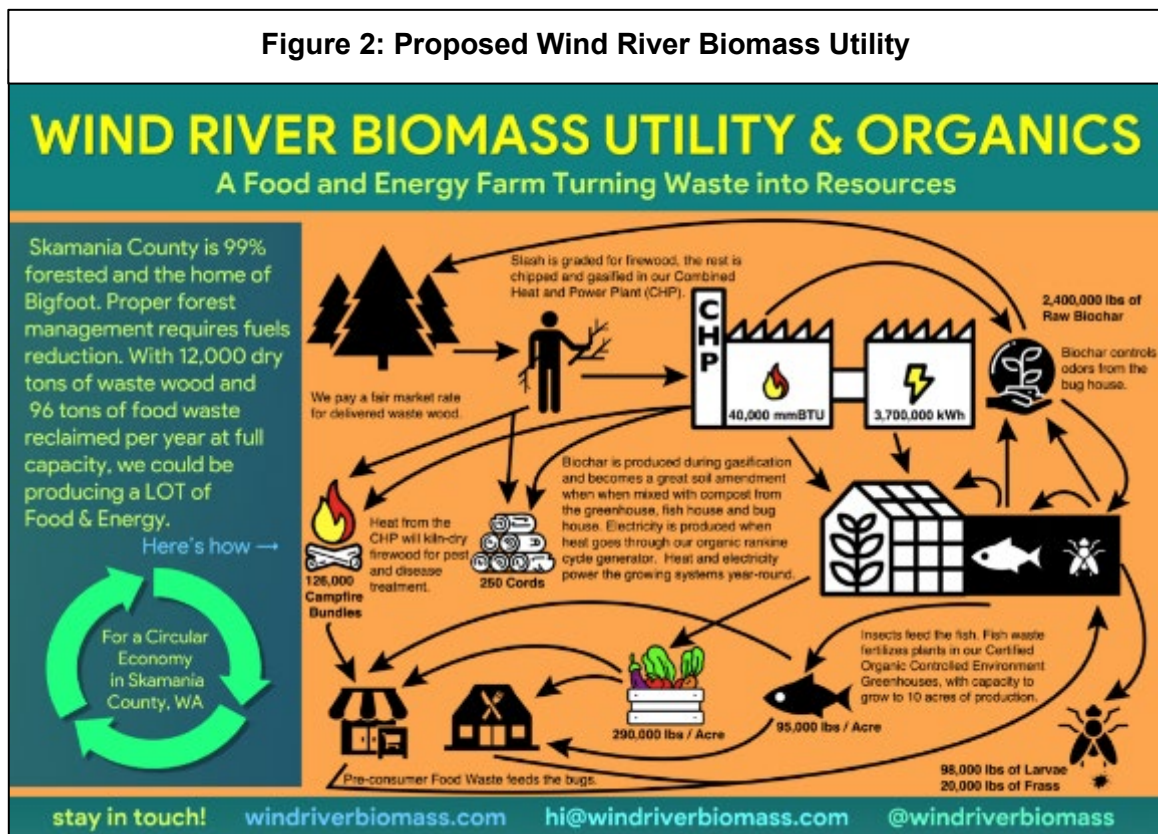
⁸ www.spokanejournal.com/local-news/-establishing-an-eco-district-in-spokane

⁹ archive.ecobuilding.org/code-innovations/case-studies/lott-methane-cogen-system



energy and agricultural products. The WRBU industrial symbiosis cluster will bring together forestry and wood products operations, a combined heat and power plant, aquaponic greenhouses, biochar production, and a kiln to dry firewood.

The WRBU reports that it has "...already secured several grants, feasibility and engineering studies, vital equipment, and waste wood..." and is seeking investors to support final design, construction, and operation. The firewood producer is now operational.



Augean Renewable Natural Gas (Yakima County)

San Francisco-based Brightmark Energy is collaborating with Promus Energy and DeRuyter Dairies to develop the Augean Renewable Natural Gas plant that will convert 150,000 gallons per day of dairy waste to 160,000 MMBtu of RNG each year, equivalent to 1.4 million gallons of gasoline. The biogas plant will also produce fiber, recover nutrients, and potentially generate other co-products as the project partners seek industrial symbiosis opportunities with other dairies in the vicinity.

Industrial Materials Exchange (King County)

The King County Industrial Materials Exchange has been running since 1991. The exchange comprises a simple portal where businesses can list or search for waste materials, hopefully making matches that divert waste from landfills. The Exchange is operated by King County's Local Hazardous Waste Manage Program, and is described as the Pacific Northwest's largest such program.



The current budget is just over \$100,000 per year (peaking at \$300,000 per year in the mid-1990s). Current solid waste diversion amounts are not reported, but based on data from 1991 to 2000 the exchange was responsible for diverting an average of about 854 tons per year (7,687 tons from 1991 to 2000). Avoided greenhouse gas emissions are not tracked. The most recent data for economic benefit also covers the 1991 to 2000 period; it was estimated business saved on average \$478,000 per year (\$4.3 million total). The number of exchanges peaked at about 400 per year in the mid-1990s, and is now estimated to be between 100 and 200 per year on average.

Specific exchanges are not currently tracked. The program was originally set up to deal with hazardous wastes, but found that most materials exchanged were non-hazardous. For years where data is available, most exchanges did not fall into available categories like "Paints and Coatings" or "Lab Chemicals" but consisted of "miscellaneous" materials.

Current listings include free sources of detergent, sanitizer, hand wash, floor finish, wax, diatomaceous earth, eucalyptus oil, and more – generally quantities are rather small (e.g., one gallon, five gallons, 50 lbs, 110 lbs).

Klickitat Renewable Energy District (Klickitat County)

CSI has been working with stakeholders in Klickitat County to explore how Klickitat Valley Health (KVH), a rural hospital, can be the hub for a renewable district energy system anchored around energy and telecommunication.

There is an opportunity to create a new energy district in parallel with KVH's new wing expansion and legacy infrastructure upgrades, that allows non-traditional energy resources and technologies for hospital resilience that can also augment energy needs of the high school, and organizations and businesses in the area. Potential project elements could include a fuel cell run on methane from the nearby Roosevelt Landfill, coupled with photovoltaic generation and batteries to supply continuous 24-hour thermal and electrical energy for the hospital's critical facilities, telemedicine and support services on the campus, and the nearby high school that doubles as a regional recovery center. By creating a flexible energy district, this hub could expand, allowing energy sources to be integrated.

The area is slated to be home for a large solar power project; the first lease of 480 acres of state trust lands for solar power is taking place in Klickitat County through the Washington Department of Natural Resources and Avangrid Renewables as part of a 150-megawatt solar power project.¹⁰ Nearby, Klickitat PUD is working with Rye Development and National Grid to develop a \$2 billion pumped storage hydropower project on the Columbia River.¹¹

In addition to energy-related symbiosis elements such as landfill gas-to-fuel cells, the region is home to a top agricultural center, which could help to catalyze material and energy-related symbiosis using wastes from the agricultural value chain. Ultimately, by blending new

¹⁰ www.dnr.wa.gov/news/franz-announces-was-first-solar-farm-lease-state-trust-lands-solar-development-klickitat-county

¹¹ www.seattletimes.com/opinion/pumped-storage-hydropower-can-help-washington-meet-its-100-clean-energy-goal



technology, locally available natural resources, and public safety demands for a remote community in rural Washington state, this project would also reduce operating costs, increase resilience, and demonstrate renewable technologies in a model replicable to rural communities across the state and elsewhere.

Carbon Fiber Symbiosis (Port Angeles)

The new Composite Recycling Technology Center in Port Angeles is transforming scrap aerospace grade carbon fiber into new products, from skateboards to strong and light wood/carbon fiber I-beams, to components for a portable pickleball court. The proposed partnership with Boeing and ELG Recycling UK will divert more than 450 tons per year of solid waste from landfill.¹²

McKinley Paper Mill Biocluster (Port Angeles)

Having recently purchased the paper mill in Port Angeles, McKinley is converting it to produce containerboard from recycled inputs. The upgrades include increasing the efficiency of the existing cogeneration boiler and recycling treated wastewater back into the plant.¹³

With its conversion to accept waste paper inputs rather than virgin fiber, the McKinley Mill is forming a kernel of industrial symbiosis from which other projects might grow. CSI has been in discussions with McKinley, the Jamestown S’Klallam Tribe’s economic development agency, Impact Washington, a leading research lab, and local economic development staff to support high-impact resource sharing opportunities, such as waste heat capture to produce algae, which the Jamestown S’Klallam Nation already produces. There may also be industrial symbiosis opportunities that overlap with the maritime industry; for example, there have been discussions regarding the use of barges to bring in the mill’s feedstock. Those barges could, in turn, use electricity and/or biofuel produced by a mill-centered biocluster.

Food Processing Value Chain Cluster (Walla Walla County)¹⁴

Walla Walla County is home to several large industries in the food processing chain, with high energy and water consumption and the generation of high-biomass wastewater and solid wastes. Given the scale and proximity of industrial operations and significance of agricultural operations in the region, there are likely industrial symbiosis opportunities. Some of the companies in the area include:

Packaging Corporation of America: This containerboard mill likely has high energy costs and is producing by-products such as waste pulp and lignin. They already capture black liquor, converting it to green liquor and then white liquor for re-use in its operations, reducing their costs and increasing their materials efficiency.

¹² investors.boeing.com/investors/investor-news/press-release-details/2018/Boeing-ELG-Carbon-Fibre-find-new-life-for-airplane-structure-material-in-groundbreaking-partnership/default.aspx and www.compositesworld.com/news/boeing-to-supply-elg-carbon-fiber-for-recycling

¹³ www.peninsuladailynews.com/news/paper-mill-prepares-to-reopen-by-end-of-year-in-port-angeles

¹⁴ Adapted from information provided by Jason Selwitz, former Faculty Lead for Energy Systems Technology, Walla Walla Community College



Tyson Fresh Meats: Tyson operates a cattle feedlot and slaughterhouse as well as a beef processing plant. There are also rendering and hide curing operations. They launched a \$36 million expansion in December 2018. The site produces wastewater and waste biomass, and also likely consumes a significant amount of energy and water.

Simplot: Simplot is planning to build a new potato processing plant. The plant will be constructed in two phases, with the first phase resulting in the largest potato processing plant in North America, and the second phase expansion creating the largest in the world.

Americold Logistics: Americold Wallula Warehouse Services offers refrigerated and frozen storage in dedicated facilities. The site also includes food processing and packing capabilities. It is also a high energy consumer, and likely produces wastewater and waste biomass.

Walla Walla Public Utilities: The WWTP was just permitted by the U.S. Department of Energy to construct pre-treatment operations to support anaerobic digesters at several other WWTPs. The landfill collects and composts yard waste. The city itself has explored bioenergy and combined heat and power opportunities.

Walla Walla Valley Wine Alliance: The Alliance comprises 150 members and community partners. The area is home to 3,000 acres of vineyards and 120 wineries. Besides input needs, these operations produce wastes such as grape pomace (spent skins, seeds, and stems). These wastes could be transformed into value-added products, such as the grapeseed oil produced by AprèsVin in the Yakima Valley.

Washington State University Biorefinery Research

Washington is a significant dairy producer, but this production also results in significant greenhouse gas emissions and waste management challenges. WSU's Center for Sustaining Agriculture and Natural Resources (CSANR) has been working with the state departments of Agriculture, Commerce and Ecology to create value from dairy wastes, helping farmers integrate additional technologies with digesters and creating dairy waste biorefineries from manure-only digester building blocks.¹⁵

By integrating with biorefineries, dairy-based digesters could expand by taking in off-farm organics like food processing wastes, generate new fertilizer products, and generate RNG. In this way, biorefineries would demonstrate industrial symbiosis as they transform dairy and other organic wastes into new products.

¹⁵ csanr.wsu.edu/dairy-waste-biorefineries

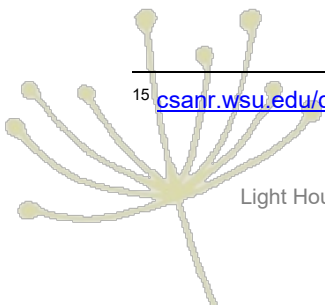
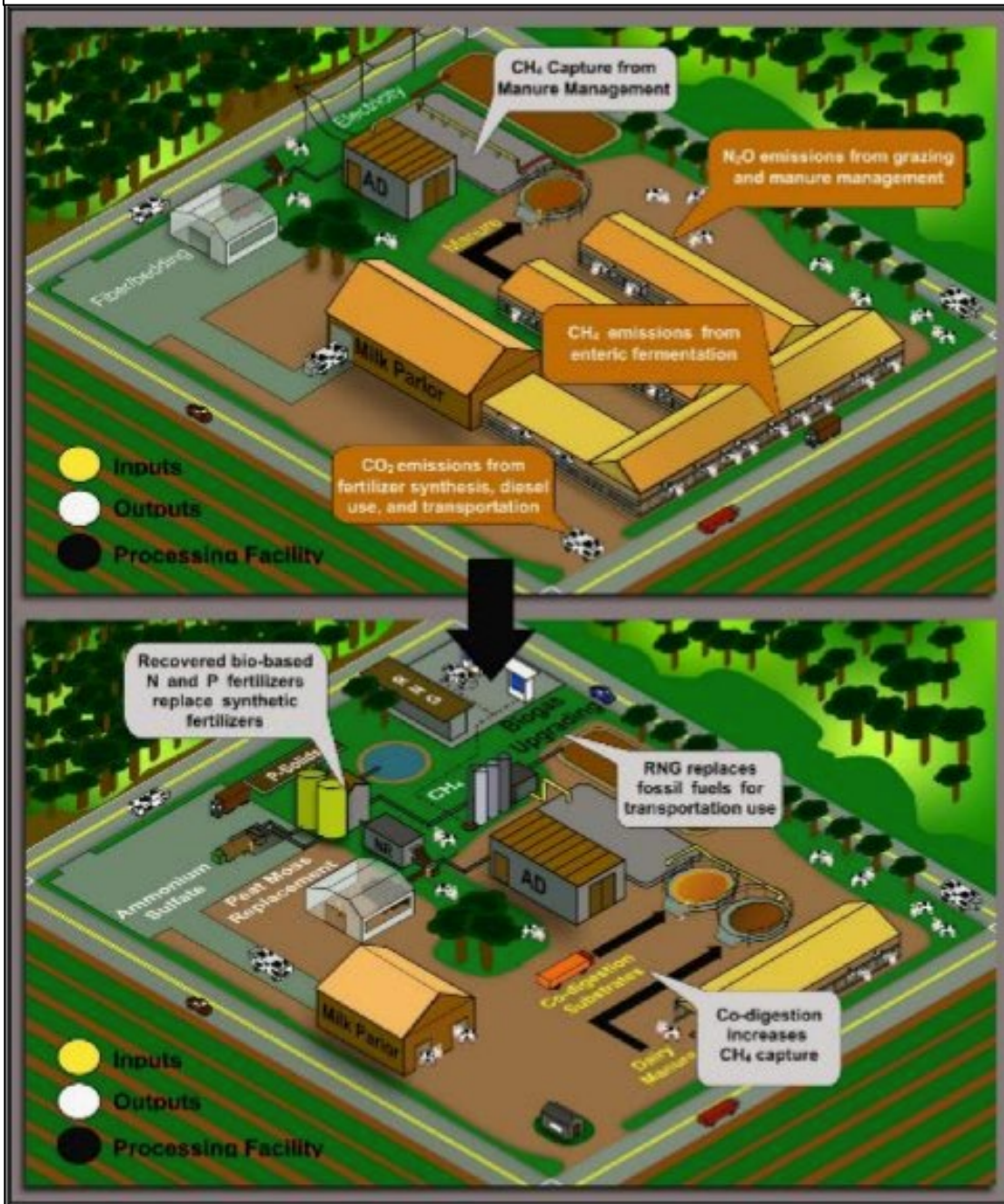


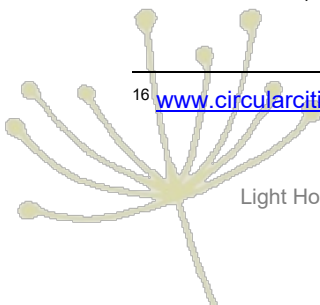
Figure 3: WSU Dairy Waste Biorefinery Concept



Circular Economy Club

The Circular Economy Club (CEC) is a not-for-profit, global network of more than 4,500 professionals from 200 cities working to advance a circular economy. Industrial symbiosis is one of the key means of achieving a circular economy. The Seattle Chapter is led by GE's Deborah Dull, principal for Supply Chain Management.¹⁶

¹⁶ www.circularcitiessattle.com



CEC Seattle participated in Circular Cities Day, hosting an event October 29 in Seattle at the Starbucks headquarters. The event highlighted Seattle's two most significant challenges, which are food and water, and presented actionable solutions and best practices. Light House staff attended the event to supplement business intelligence for this report.

Speakers included John Phillips, director of Integrated Watershed Management for Parametrix, who formerly spent 20 years with King County's water department. John presented information regarding regional WWTP circular design processes (e.g., biogas and biosolids initiatives). Brad Liljequist, Zero Energy senior program manager with McKinstry, spoke about zero energy building. McKinstry is developing the high-performance Catalyst Building in the West Plains Innovation Park in Spokane. Rob Pena, associate professor of architecture at the University of Washington, presented about the world's greenest office building, the Bullitt Center. Kamal Patel, Civic and UX designer for the city of Seattle, shared the best circular practices of Seattle urban food supply chains, including examples from Cedar Grove Composting, University District Food Bank, and Matsuda Farm. Lauren Acoba, senior group manager for the Global Food Supply Chain, and Chris MacFarlane, project manager for Global Social Impact and Public Policy of Starbucks, shared Starbucks' sustainability initiatives and the NEXTGEN consortium.

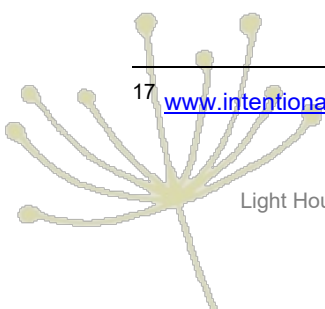
Besides the presentations and local showcases, we had a chance to meet with two King County employees, Emily Coleman, Sustainable Purchasing and Recycling Market Development specialist, and Andy Smith, Zero Waste Market program manager. They both noted that the new Recycling Development Center in King County might be relevant to state industrial symbiosis efforts.

We met with many local small and medium-sized enterprises and technology companies that implement circular thinking in their businesses. Westland Distillery uses treated wastewater in the distillation process. Armoire is a high-tech clothing rental platform that provides "slow fashion" options focused on quality, environmental impacts, and fair trade. Intentionalist¹⁷ is an online guide to intentional spending that supports small businesses and diverse local communities. We also met with such leading global business as Starbucks, General Electric, and Philips.

The event amplified the support for industrial symbiosis expressed by the participants of the NISP® test-drive workshop. The event also underscored the diverse foundation for industrial symbiosis in the state. By no means must industrial symbiosis start from scratch; there are numerous public and private sector initiatives that require further connection, coordination, and expansion.

The CEC Seattle Chapter is a very strong potential supporter and implementation conduit of industrial symbiosis in Washington. Their next event is a Circular Economy mapping session in February 2020.

¹⁷ www.intentionalist.com



Existing Policy Foundation

In addition to Washington industrial symbiosis activity, there is already a foundation of industrial symbiosis policy in place. A full policy alignment evaluation was not within the scope of this study, but may be helpful in the future. Examples of some current policies that might be linked to an industrial symbiosis program are presented below.

Sustainable Recycling (E2SHB 1543):

Creates a Recycling Development Center within Ecology to further the development of markets and processing for recycled commodities and products. An interagency agreement with Commerce will include assistance to recycling businesses, outreach to manufacturers to increase use of recycled materials, and promotion of manufacturing with recycling materials.

Industrial Symbiosis Connection: Could Industrial Symbiosis facilitators be housed here? Could an RD&D fund like Circulate (Australia) be run through the center? Could the Center support product development from MSW streams, such as the waste polystyrene to concrete symbiosis catalyzed by Fors A/S in Denmark?

Plastic Stewardship (E2SSB 5397):

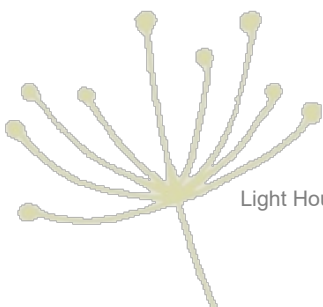
Ecology must evaluate and report findings and recommendations by November 2020 on the amount and types of plastic packaging sold into the state, as well as its management and disposal. The report must include final disposition of plastic packaging, identification of businesses that use recycled plastic as a feedstock, and a review of industry efforts and innovations to reduce, reuse, and recycle plastic packaging.

Industrial Symbiosis Connection: Integrate plastics packaging flow data into any industrial symbiosis databases; liaise with Industrial Symbiosis facilitators to make connections with businesses that might have or use plastic packaging wastes.

Food Waste Reduction (E2SHB 1114):

Ecology, in consultation with Agriculture and Health, must adopt a wasted food reduction and food waste diversion plan by October 2020 intended to reduce waste by 50% by 2030. To support the plan, Commerce is contracting for an independent evaluation of the state's food waste and wasted food management systems.

Industrial Symbiosis Connection: Integrate data into any industrial symbiosis ICT. Facilitators can connect businesses that might have or use food wastes. Integrate food waste reduction efforts with bioenergy strategies. Support cross-sector opportunities, e.g., food waste to nutraceuticals production.



Building Efficiency (E3SHB 1257): Gas companies must identify and acquire all available and cost-effective conservation measures (taking into account the societal costs of greenhouse gas emissions) based on biennial acquisition targets. Gas companies may propose an RNG program as part of their compliance plan, and they must offer by tariff a voluntary RNG service to retail customers.

Industrial Symbiosis Connection:
Facilitated industrial symbiosis can help uncover bio-based feedstocks for RNG production, and help identify new feedstock clusters, especially in the “urban” agricultural value chain.

Clean Energy Transformation (E2SSB 5116): Among the many components are: 1) a directive to Commerce to review the state energy strategy to align it with this act and Ecology’s recommended greenhouse gas emission reductions by end of 2020, and at least once every eight years thereafter, and 2) creation of a policy advisory committee (including four-year higher education institutions and Pacific Northwest National Lab) to examine costs and benefits of energy-related policies and develop recommendations by end of 2020.

Industrial Symbiosis Connection:
Although they don’t produce many “shovel and ribbon-cutting” projects, facilitated industrial symbiosis programs significantly reduce greenhouse gas emissions by diverting organic waste from landfills, increasing renewable energy generation, reducing transportation of materials and wastes, and increasing fuel substitution opportunities.

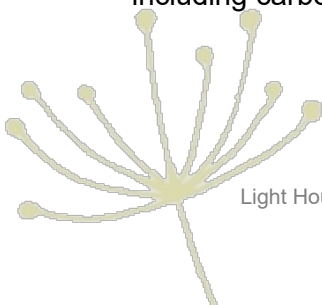
From the operating budget (ESHB 1109), the following initiatives can also be considered:

Green Economy Work Group: Commerce has convened a work group to make recommendations for green economic development investment opportunities, with a preliminary report due December 1 and final report next July. The group will build on the outcomes of the Association of Washington Cities’ report titled *Growing the Green Economy: Exploring an Eco-Nomic Center*.

Industrial Symbiosis Connection:
Facilitated industrial symbiosis engages businesses of all sectors in activities that reduce their environmental impact (with economic benefits). Facilitated industrial symbiosis can focus on symbiosis involving certain resources or sectors, e.g., food and agriculture.

Sustainable Farms & Fields: The Washington Conservation Commission and Department of Agriculture are developing recommendations for legislation or additional work needed to implement a grant program prioritizing reduction of greenhouse gas emissions on farm, aquatic and ranch lands, including carbon sequestration.

Industrial Symbiosis Connection: The agriculture and agriculture value chains lend themselves well to industrial symbiosis activity. Most of the resources tabled in the NISP® Canada pilot were either wood or food and agriculture-related. As the WSU biorefinery work and case studies show, agricultural activity is quite amenable to industrial symbiosis activity.



NISP® ‘Test-Drive’ Workshop Outcomes

NISP® Canada and CSI hosted a “test-drive” NISP® workshop near SeaTac Airport on October 3. With an outreach lead time of only four weeks, compared to the normal two to three months, nearly three dozen parties representing a wide variety of businesses and organizations expressed interest in participating in the Seattle workshop. On the day itself, 20 parties attended, representing 19 different businesses or organizations.

The workshop demonstrated how facilitated industrial symbiosis could quickly increase the number of businesses engaged in industrial symbiosis and accrue the commensurate benefits. There are now businesses working with NISP® Canada facilitators to pursue symbiosis opportunities that could avoid 23,000 tons of greenhouse gas emissions and divert almost 95,000 tons of solid waste from landfills.

In addition to the usual goal of obtaining detailed information on the resource “haves” and “wants” of attendees, the workshop was also used to collect the perspectives on industrial symbiosis in Washington state. The latter were collected by means of a detailed feedback form completed by all attendees.

The following organizations were represented at the workshop:

Ameresco	City of Tacoma
CompostNow	Center for Sustainable Infrastructure
dJoule / IMC Energy and Environment Mukilteo	Earth Homes LLC
Georgetown Brewing	Human Partners
Impact Bioenergy	OCO Inc
Pacific Northwest National Laboratories	Platinum Group LLC
Seattle Public Utilities	Seattle Southside Chamber
Simontic Composite	Tacoma Pierce County Chamber
Washington Department of Commerce	Washington State Microenterprise Association

Even with this relatively small group, the facilitated approach used at the workshop revealed 90 distinct resources and generated 140 initial matches (industrial symbiosis opportunities), represented in Figure 4. A one-page summary of the workshop’s highlights is included in Appendix C of this report.

Of the 95 resources, 36 were conventional materials, water, and energy resources, 28 represented surplus assets or operational capacity (e.g., surplus equipment, equipment down-time, surplus land, logistical), and 31 represented expertise.

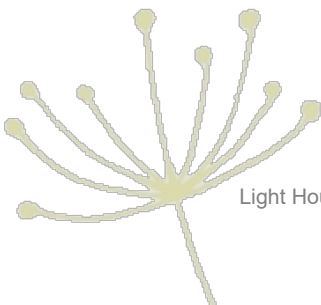
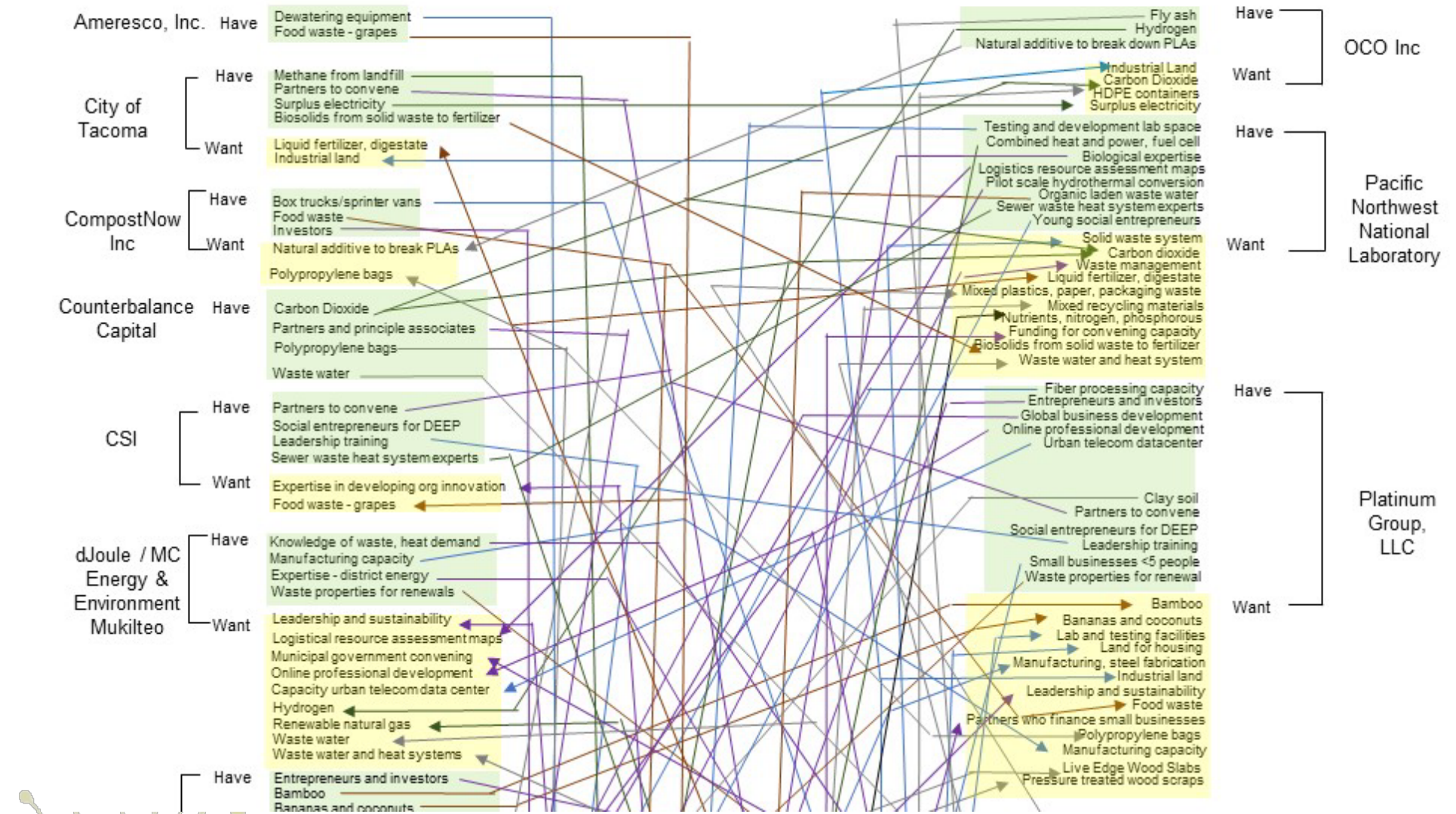
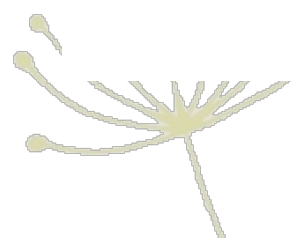
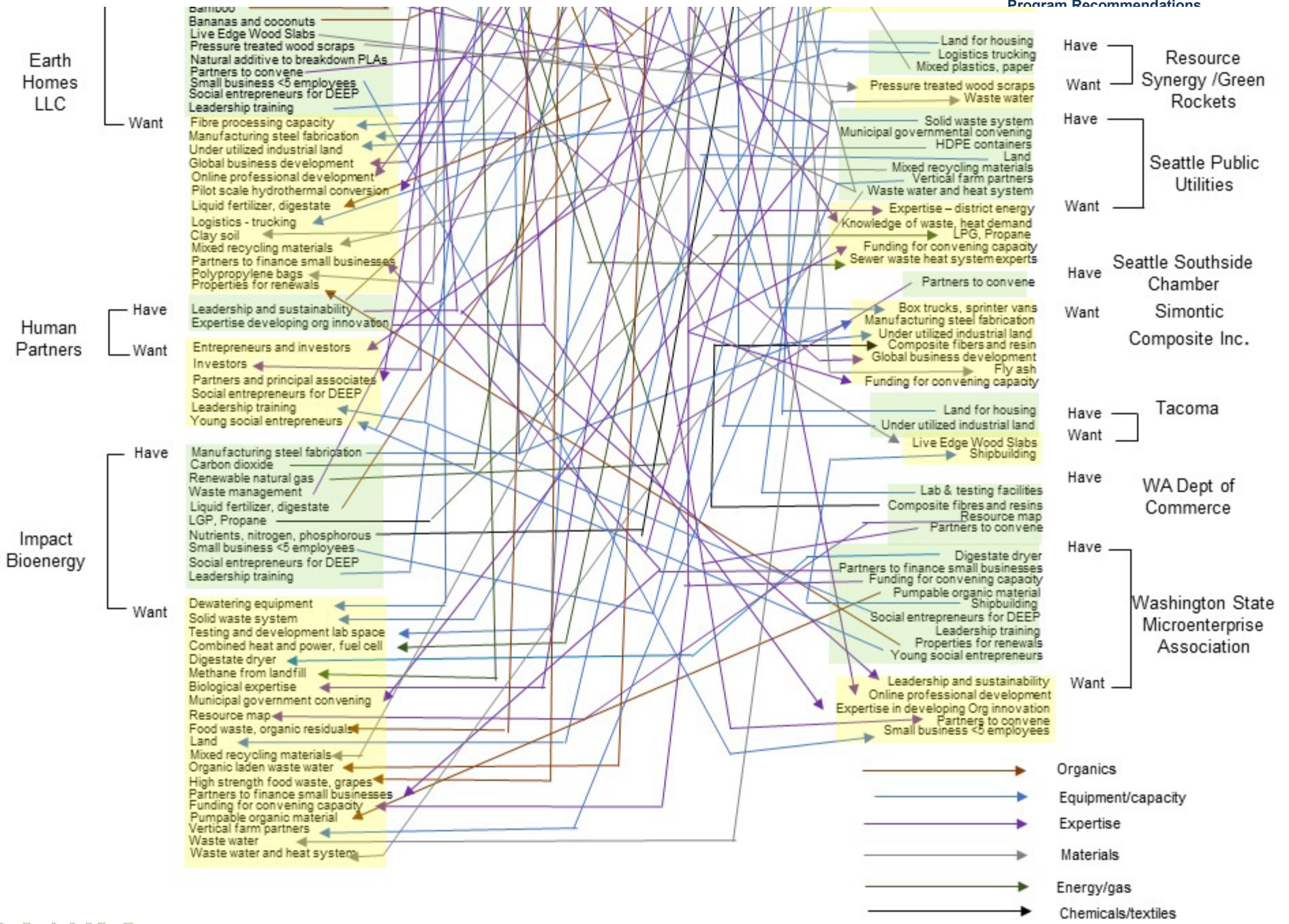


Figure 4: MindMap™ of Seattle Workshop Matches





Some of the underutilized resources put forth by the workshop participants are listed below. As was seen in NISP® Canada, many resources are bio-based:

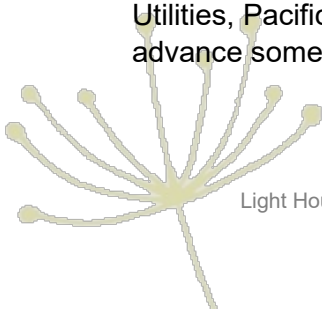
Bamboo	Bananas and Coconuts
Box Trucks and Sprinter Vans	Carbon Dioxide
Composite Fibers and Resin	Combined Heat & Power or Fuel Cell
Landfill Methane	Digestate Dryer
Fly Ash	Renewable Natural Gas
HDPE Containers	Food Waste Organic Residuals
Hydrogen	Urban Telecom Datacenter
Land	Surplus Electricity
Trucking Logistics	Liquid Fertilizer, Digestate
Manufacturing Capacity	Propane
Pressure Treated Wood Scraps	Wood Slabs, Artisan Finishing
Mixed Plastics, Paper Package Waste	Clay Soil
Natural Additive to Break Down PLA	Mixed Recycling Materials
Organics-laden Waste Water	Nutrients (nitrogen, phosphorus)
Polypropylene Bags	High-strength Food Waste (grapes)
Biosolids	Pumpable Organic Material
Waste Water and Heat	Vertical Farm Technology

The NISP® model has been recognized as advancing innovation, e.g., knowledge transfer across sectors or catalyzing new product development. Some of this success ties back to the ability of the program to tease out not just “waste” or surplus materials, water and energy resources, but also capacity and expertise. This can be particularly valuable to small and medium-sized enterprises. Some of the expertise matched at the workshop included:

Biological Expertise	District Energy
Global Business Development	Waste and Heat Demand
Leadership & Sustainability	Logistical Resource Assessment Maps
Municipal Governmental Convening	Online Professional Development
Pilot-scale Hydrothermal Conversion	Resource Map
Waste Management	Developing Organizational Innovation

On October 29, we met with two workshop attendees to follow up on symbiosis opportunities. The first was Earth Homes, which creates green, healthy and regenerative earth homes. Earth Homes uses natural materials and was looking for bamboo, hemp and other plant-based waste resources to mix with clay to build earth homes. The founders were interested in trying fly ash or waste composite fiber resin resources from Simontic Composite, a match made during the workshop. We also met with Impact Bioenergy, which has available space in its manufacturing facility that Earth Homes may be able to utilize. These symbiosis opportunities will be on their way to implementation by the end of this year.

We are continuing to communicate with Georgetown Brewery, Simontic Composite, Washington State Microenterprise Association (WSMA), City of Tacoma, Seattle Public Utilities, Pacific Northwest National Laboratory, Impact Bioenergy, and Earth Homes to advance some of their symbiosis opportunities.

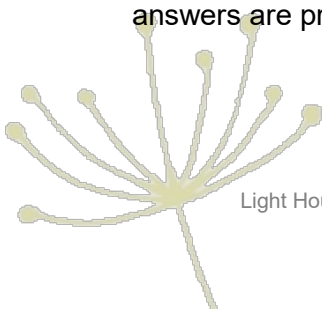


Feedback regarding the workshop itself underscores the value of facilitated events in identifying industrial symbiosis. Participants responded to “In what ways has the workshop benefited your business or organization?”

“Ideas for replicable partnerships. Language to use in order to inspire others to consider this framework.” <i>J. Senkbeil, Compost Now</i>
“Awareness of solutions and needs; ability to network with businesses.” <i>N. Bennette, Counterbalance Capital</i>
“Connections, new way of thinking.” <i>E. Moe, dJoule/UMC</i>
“Connections / networking; opportunities to collaborate. Exposure. Fun!” <i>M. Rasmussen, Earth Homes LLC</i>
“Networking in our types of industries; match-making! Business development.” <i>S. Kumar, Impact Bioenergy</i>
“Networking – meeting potential partners.” <i>M. Smith, Impact Bioenergy</i>
“New ideas about what resources can be shared (like heat).” <i>M. Neal, MIC, Tacoma Chapter</i>
“Connections, knowledge.” <i>S. Edmundson, PNNL</i>
“To get info on status of state’s interest and plans for research and [this] program. To meet the players. To understand NISP process for tackling the goals.” <i>B. Zak, Resource Synergy</i>
“Highly beneficial in connecting potential businesses together.” <i>S. Senibi, Simontic Composite</i>
“Better understanding of how we define industrial symbiosis. How do opportunities come together?” <i>B. Young, Wash. Dept. of Commerce</i>
“I learned new information and made new connections with potential partners.” <i>L. Smith, WSMA</i>
“Hope to connect and encourage other businesses for greater input.” <i>Anonymous</i>
“We hope to learn more to better serve our industries.” <i>A. Reay, Seattle South Chamber</i>

Additional workshop stakeholder feedback

The workshop feedback form contained three questions aimed at eliciting from participants their perspectives on industrial symbiosis and its potential in Washington. The questions and answers are presented below.



Workshop participants were asked to rate a number of factors that could potentially support industrial symbiosis in Washington, with “1” indicating the factor was not important and “5” indicating the factor was very important. The top three factors were:

- Business match-making support
- Access to capital; and
- Public sector and utility pilot and demonstration projects.

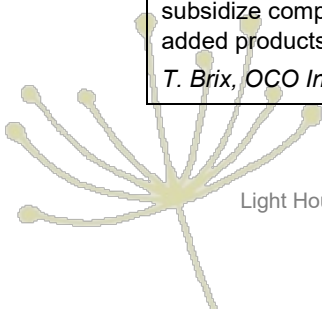
It is interesting that public and utility pilots ranked higher than other business pilots. This matches the evolution of green building, where the first projects were government buildings, allowing the public sector to absorb some learning curve risk and innovation costs before the private sector was comfortable. The overall ranking of industrial symbiosis factors is presented in Table 2, with all factors deemed important to some extent.

Table 2: Participant Feedback on Factors Influencing Industrial Symbiosis

Factors Influencing Industrial Symbiosis in Washington	Mean response
Business match-making support	4.6
Access to capital	4.5
Pilot / demo projects – Public / Utility	4.4
Pilot / demo projects – Business	4.3
Materials databases	4.3
Market demand for eco / recycled content products	4.2
Attracting new business in my value chain	4.2
Skill / knowledge of my existing workforce	4.0
Transportation Infrastructure	3.9
Availability of / attracting additional skilled workforce	3.7
R&D support	3.7
General “I’m too busy and need help” support	3.7

Participants were also asked an open-ended question: “**What could the state best do to advance industrial symbiosis?**”

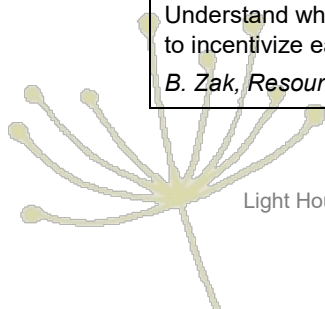
<p>“Continue to facilitate these events and expand participation/network.” <i>M. Greenwood, Ameresco</i></p>	<p>“Fund it, think at scale, and appreciate thermal energy as a waste resource.” <i>E. Moe, dJoule/UMC</i></p>
<p>“Connect with entities that have done or are doing it now and gather lessons learned. Obtain data on how industrials would conduct business using a program like this. Establish incentive programs (like was done for energy efficiency). Fund the effort long enough to gain traction.” <i>B. Zak, Resource Synergy</i></p>	<p>“More of this! These workshops are so dynamic and generative. Incentivize companies to have / find symbiotic uses for waste products. Make SYNERGie 4.0 database available freely to industry and make it searchable.” <i>M. Rasmussen, Earth Homes LLC</i></p>
<p>“Tax all carbon emissions. Use tax revenue to subsidize companies which utilize CO₂ to make value-added products.” <i>T. Brix, OCO Inc.</i></p>	<p>“Convene and connect business, government, and technological innovation.” <i>R. Paine-Donovan, Seattle Public Utilities</i></p>



<p>“Experiment, fund development, measure benefits, re-assess.” <i>G. Grant, Human Partners</i></p>	<p>“Incentivize circularity! Local / hyper-local solutions should be the goal.” <i>S. Kumar, Impact Bioenergy</i></p>
<p>“Leverage resources and contacts to move WA to the lead.” <i>D. Seydel, Platinum Group</i></p>	<p>“Incentivize waste divergence (including CO₂), recycling, and avoidance.” <i>S. Edmundson, PNNL</i></p>
<p>“Continue to facilitate conversations and look for ways to incent manufacturing to participate.” <i>Anon.</i></p>	<p>“Connecting opportunities. Providing asset maps for companies.” <i>B. Young, Wash. Dept. of Commerce</i></p>
<p>“Open forum / platform for sharing needs / wants, curated to ensure compliance (e.g., no marketing). Help connect capital and partners.” <i>N. Bennette, Counterbalance Capital</i></p>	<p>“Give grants to enable companies scale up products for national and international markets, and employ and train workers in WA state.” <i>S. Senibi, Simontic Composite</i></p>
<p>“Build trust with traditional manufacturing and industrial businesses so they will share their waste streams and provide incentives to build capacity to use other industrial waste.” <i>M. Neal, MIC, Tacoma Chapter</i></p>	<p>“Provide grants to partners that fund TA to businesses around the state for waste exchange. Offer more of these types of workshops. Work with partners to establish competition that highlights matches that can be replicable.” <i>L. Smith, WSMA</i></p>
<p>“Industry leaders that reach out and work with / help / steward this process for small business. Contracting companies (local builders) come to mind.” <i>A. Sauerhoff, City of Olympia</i></p>	<p>“Adopt in policy at state and city level.” <i>M. Smith, Impact Bioenergy</i></p>

Lastly, participants were provided with space to provide any other comments regarding the event or their hopes for industrial symbiosis in the state.

<p>“Continue to build networks and elevating this opportunity. Good work!” <i>J. Senkbeil, Compost Now</i></p>	<p>“I would like to learn more.” <i>A. Reay, Seattle South Chamber</i></p>
<p>“Thoughtful creative collaboration like this should become first-rate standard practice. Engaging in the process should be required for any company / industry seeking to export waste. Knowledge of this database and process should be communicated to all registered businesses in relevant sectors and be communicated to all new businesses undergoing registration.” <i>M. Rasmussen, Earth Homes LLC</i></p>	<p>“Good event to get my brain thinking about this in a different way – I see this as Phase 1. Getting traditional businesses [to participate] will be difficult since they often don’t want to share to a public database. Building trust will be key. Looking forward to seeing where this goes.” <i>M. Neal, MIC, Tacoma Chapter</i></p>
<p>“SYNERGie 4.0 should be shared and utilized.” <i>S. Kumar, Impact Bioenergy</i></p>	<p>“Become a leader in industrial symbiosis nation-wide.” <i>M. Smith, Impact Bioenergy</i></p>
<p>“It was great! Olympia would be happy to talk about hosting the next one.” <i>A. Sauerhoff, City of Olympia</i></p>	<p>“Very good and helpful event.” <i>S. Senibi, Simontic Composite</i></p>
<p>“Must cooperate with other states / regions. Understand where catalytic funding should be applied to incentivize early adopters.” <i>B. Zak, Resource Synergy</i></p>	<p>“Codified process.” <i>E. Moe, dJoule/UMC</i></p>



Industrial Symbiosis Program Recommendations

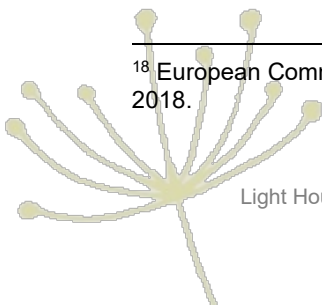
There is a clear and compelling case and precedent for the State of Washington to support an industrial waste coordination (industrial symbiosis) program. In fact, based on the escalating level of industrial symbiosis and circular economy activity worldwide, an industrial symbiosis program is an important tool to ensure continued economic competitiveness.

Whether it be a Danish task force that concluded that shifting to a circular economy could increase Denmark's GDP by 1.4% per year by 2035, the evidence gathered during the Danish study tours, or the results reported in case studies, governments around the world are supporting industrial symbiosis as a means of driving economic prosperity and diversification, as well as improving environmental performance and driving innovation. The case studies demonstrate that financial support from governments for industrial symbiosis is indeed an investment, not a subsidy, returning multiple times the economic and environmental value. The NISP® Canada pilot demonstrated that government investment created seven times its value in economic returns (see Case Studies), which was the same as that originally demonstrated by NISP® UK.

Drawing from best practice, which was recently articulated in the European Committee for Standardization *Industrial Symbiosis: Core Elements and Implementation Approaches*¹⁸, key principles for any Washington Industrial Symbiosis Program are presented below:

Principle 1:	Support the identification <i>and implementation</i> of industrial symbiosis.
Principle 2:	Include some element of facilitation. Facilitated programs have been demonstrated to engage the most businesses and achieve greater economic and environmental outcomes.
Principle 3:	Engage a diversity of participants from the private sector, utilities, government and academia. <i>"A diverse network engaging business across all sectors and sizes, research and the government has proven to foster knowledge transfer and demand-led innovation by bringing together the companies with real problems, and the researchers able to address, and sometimes resolve, them. In the UK's NISP experience, over 70% of synergies have been shown to involve some form of innovation: 50% cross-sector knowledge transfer and best practice, and 20% new research and development deriving from close links with universities."</i>
Principle 4:	Be state supported and coordinated but focus on regional implementation reflecting different regional economic strengths as well as the geographic limits for many industrial symbiosis projects. <i>"Regional economic development that draws on existing key industrial activity and resource streams can lower the carbon footprint of development, while strengthening local economies through improved material and energy security."</i>
Principle 5:	Establish quantitative metrics with corresponding monitoring requirements and ICT support.

¹⁸ European Committee for Standardization (CEN) Workshop Agreement (CWA) 17354 ICS 13.020.20, December 2018.



Keeping in mind the above principles and drawing from global best practice reflected in the case studies and our professional experience, we recommend that the State of Washington take the following action to establish an industrial symbiosis program.

Firstly, because facilitated industrial symbiosis can be activated at any time without requiring regulatory changes or capital investment, we recommend that Washington invest in a facilitated industrial symbiosis program and launch a preliminary RD&D program. With those efforts proceeding and securing short-term benefits, efforts to grow the state's clean energy and integrated utility sectors can continue while a more robust policy framework and RD&D program are developed.

1. Invest in Facilitated Industrial Symbiosis

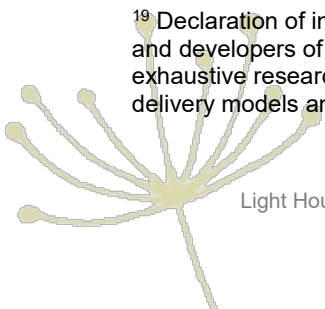
The state of Washington should provide multi-year investment for facilitated industrial symbiosis that includes public and private sector operations and that reaches multiple regions. A recent NISP® model “test-drive” for public and private entities in Washington demonstrated how facilitated industrial symbiosis can quickly increase the number of participating businesses and accrue the commensurate benefits. Based on limited early data, opportunities were identified that could eliminate 23,000 tons of greenhouse gas emissions and divert almost 95,000 tons of solid waste from landfills.

Rationale for a Facilitated Industrial Symbiosis Program

A facilitated industrial symbiosis program allows for Washington to take immediate industrial symbiosis action with short-term economic and environmental benefits. A facilitated industrial symbiosis program can be launched without requiring regulatory changes. Furthermore, facilitated industrial symbiosis programs can be implemented even while the market, regulatory, and investment development required to advance large-scale industrial symbiosis projects, such as biorefineries or integrated utility resource recovery facilities, are advancing, and are not mutually exclusive of these more capital-intensive efforts. In fact, facilitated industrial symbiosis programs can provide additional support to large-scale industrial symbiosis projects, e.g., through the identification of unique biomass waste streams and other feedstocks as well as identifying potential markets for residues. Several international evaluations have determined that the NISP® model, which is based on facilitation, has demonstrated the best outcomes of any industrial symbiosis approach (see Appendix B for a related feasibility study).¹⁹

Facilitated industrial symbiosis programs have generally created the greatest environmental and economic outcomes (solid waste diverted, greenhouse gas emissions avoided, cost savings and new sales while also stimulating private investment in the implementation of synergies) over the shortest amount of time. They allow for the participation of businesses of all sizes and sectors, including utilities and small and medium-sized enterprises while also providing facilitators the opportunity to focus on engaging specific sectors to address specific

¹⁹ Declaration of interest: International Synergies Ltd. (a member of the report consulting team) are the owners and developers of the NISP® model and SYNERGie® ICT platform. Based on decades of experience and our own exhaustive research, Light House firmly believes the above analysis accurately reflects the state of play regarding delivery models and ICT systems relevant to industrial symbiosis.



stakeholder objectives. For example, the NISP® Canada pilot was partially funded by the BC Ministry of Agriculture, which requested that facilitators make extra efforts to ensure the participation of businesses from the agriculture value chain. See Appendix B for the detailed feasibility study completed by Light House in 2016, and Appendix C for the December 2018 European Commission for Standardization Committee Workshop Agreement for Industrial Symbiosis: Core Elements and Implementation Approaches, which functions as a pre-standard for all EU member country industrial symbiosis programs.

For these reasons, the CEN-CWA 17354 lists **facilitation as a key element of any industrial symbiosis program**, as do the EU Circular Economy requirements.

Once the success of NISP® UK became publicly documented via the *Pathways to a Low-Carbon Economy* report, which presented the results of a third-party verification and audit of the program’s first five years of results, interest in the NISP® model increased, and it is now recognized that NISP® is the most successful facilitated industrial symbiosis model globally, with adaptations in 35 countries at local, regional or national levels. The success of NISP® model actually underpins EU support for facilitated industrial symbiosis; even Denmark, with its pioneering industrial symbiosis demonstrated in Kalundborg, is part of the CEN which developed the CEN-CWA 17354.

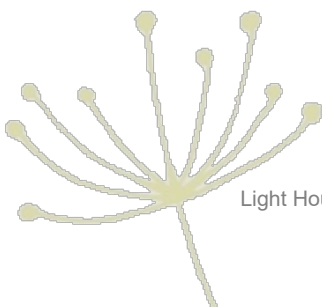
Facilitated Industrial Symbiosis – Structural Models

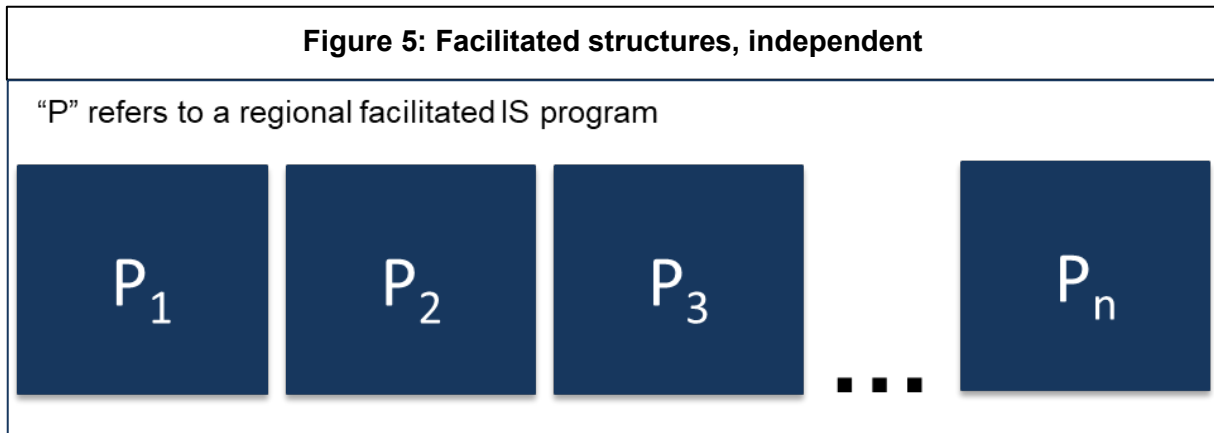
As facilitated industrial symbiosis has been implemented across numerous countries, different organizational structures have been used. Models relevant to the State of Washington are discussed below:

Model 1: Independent delivery across multiple, unconnected activities

Under this model, regional programs emerge organically, often inspired by the success of an original regional effort (see Figure 5). Presumably over time, there is more information sharing and cooperation, but there is no one body responsible for consistency or quality control. Each program employs or contracts for its own facilitators, and **independently** establishes and plays the following roles:

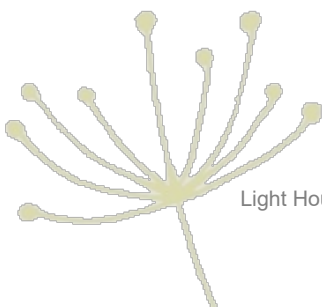
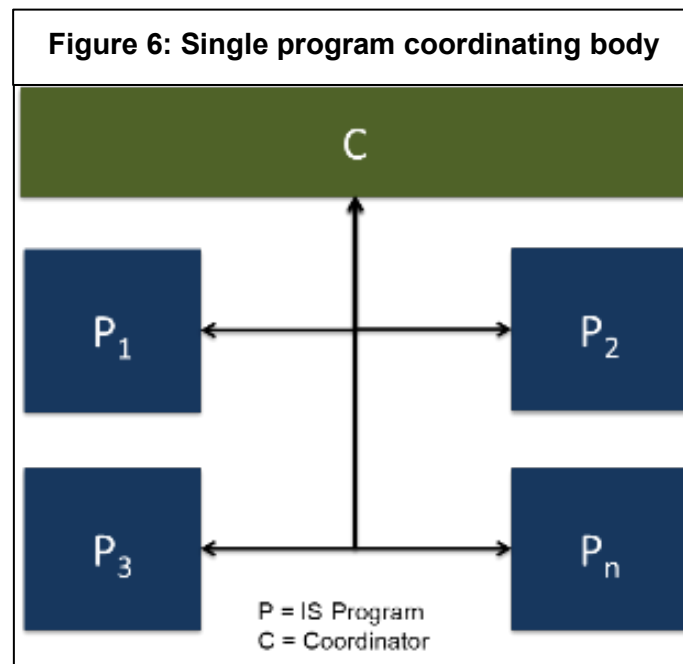
<ul style="list-style-type: none"> • Program management 	<ul style="list-style-type: none"> • Program development
<ul style="list-style-type: none"> • Recruitment of practitioners 	<ul style="list-style-type: none"> • Training
<ul style="list-style-type: none"> • Stakeholder engagement and agreement on key performance indicators 	<ul style="list-style-type: none"> • Providing or procuring expertise and support
<ul style="list-style-type: none"> • Branding and communication 	<ul style="list-style-type: none"> • Database management
<ul style="list-style-type: none"> • Monitoring, evaluation and reporting 	<ul style="list-style-type: none"> • Methodologies, processes and standards
<ul style="list-style-type: none"> • Raising funds 	





Model 2: Single program coordinator body

The most common start-up and “early years” model. A lead coordinator organization (private or public) secures funding to deploy programs in several regions. Although some funding might come from regional partners, all funding flows to the coordinator. Under this model, the coordinator oversees the delivery of multiple regional programs, where each program is virtually identical. Regional facilitators are employed by or directly contracted to the coordinator. This was the model used to launch NISP[®] Canada.



The Coordinating Body is responsible for the following:

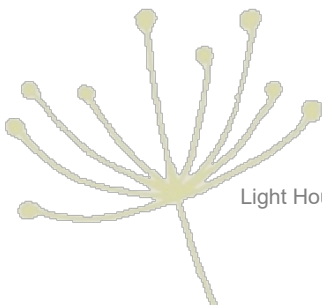
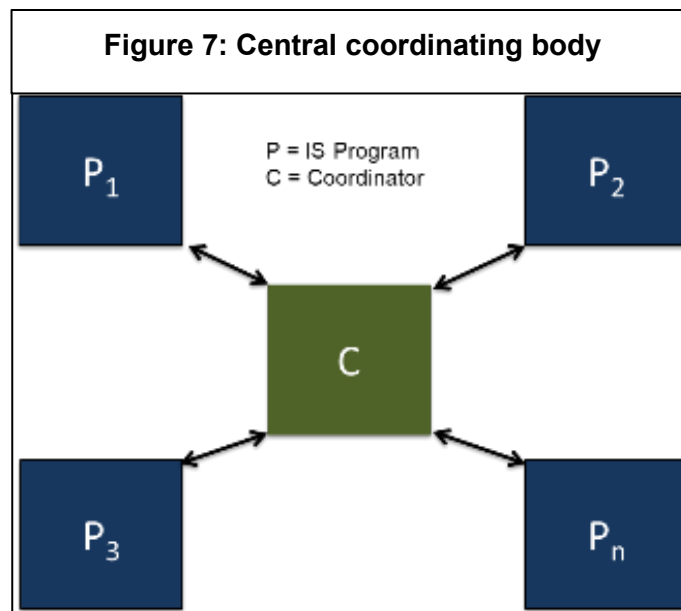
• Program management	• Methodologies, processes and standards
• Raising funds	• Stakeholder engagement and agreement on key performance indicators
• Recruitment of practitioners	• Training
• Database management	• Providing or procuring expertise and support
• Branding and communication	• Monitoring, evaluation and reporting
• Program development	

Model 3: Central coordinating body

Under this model, the **central coordinating body** is responsible for:

• Program management	• Methodologies, processes and standards
• Raising funds	• Stakeholder engagement and agreement on key performance indicators
• Recruitment of practitioners	• Training
• Database management	• Providing or procuring expertise and support
• Branding and communication	• Monitoring, evaluation and reporting
• Program development	

The coordinator manages each regional program on behalf of regional partners (including region-specific funders). Facilitators (or facilitation delivery partners) are sub-contracted to the coordinator, and are responsible for delivering the program regionally, but not for securing funding.

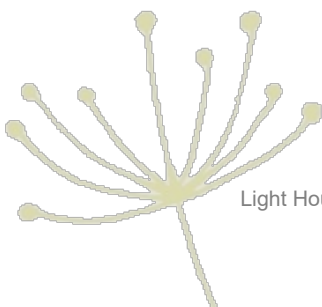


Multi-region delivery is preferred: Ultimately, a facilitated industrial symbiosis program in Washington should provide coverage across the state. The case studies and our experience show that regional delivery is key, allowing for the ability of facilitators to practically engage with businesses and for businesses to participate in matchmaking workshops. Regional delivery also reflects the impact of transportation costs on the viability of many symbiosis opportunities.

Coordinated regions ensure consistency and quality control: Coordination may be required to ensure any state investment is deployed efficiently and effectively. There are likely some inter-regional symbiosis opportunities that make business sense, as was seen in previous multi-region programs such as NISP® UK. Regional facilitators may also be able to exchange knowledge regarding overcoming common barriers. Coordination of multiple regional sub-programs also supports state-level performance reporting and policy alignment. Coordinated regions also have a higher degree of efficiency and lower net cost, as there is no need to replicate specific expertise in every region and regional facilitators can use a uniform platform and the same marketing materials.

A Coordinator could be public or private. The organizations housing a facilitated industrial symbiosis program can be government agencies, such as Invest Northern Ireland, which has been the face of a facilitated industrial symbiosis program since 2007 (see The [Invest NI] Industrial Symbiosis Service case study) or the arms-length National Center for Cleaner Production in South Africa. Coordinators could also be utilities. Given their direct connection to probably thousands of commercial and industrial customers across all sectors and sizes, private or publicly owned utilities should be in a position to facilitate industrial symbiosis, whether through the deployment of a formal program such as NISP® or on a smaller scale. For example, the municipally owned water, wastewater, district heating, and solid waste utility Fors A/S (see the case study in Appendix C) provides free facilitation to its business customers and has helped several of its customers establish industrial symbiosis, e.g., supporting the recovery of waste polystyrene to blend into a lightweight concrete building material or recovering waste heat from a food manufacturer to augment Fors' district heating system. Facilitated industrial symbiosis programs can also be housed in private NGOs, as was the case for Light House Sustainable Building Centre Society's NISP® Canada, or research institutions, such as Curtin University's work with the Kwinana Industries Council in Australia.

Program Advisory Groups (PAGs): Most structures include PAGs at the regional and/or coordinating body level. PAGs can increase program participation by acting as ambassadors. PAGs provide business steerage on local factors that might impact program participation or delivery. PAGs can also connect facilitators and businesses to relevant parties to help implement symbiosis opportunities.



Facilitated Industrial Symbiosis – Investment Requirements

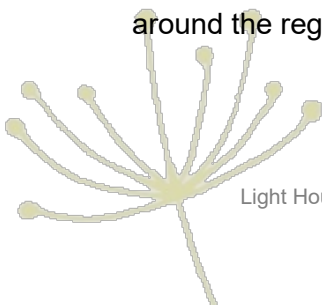
Long-term, multi-year government investment in facilitated industrial symbiosis programs has proven very successful (e.g., NISP® UK, SWIX Florida, The [Invest NI] Industrial Symbiosis Service, FISS Finland, WISP/GISP South Africa). Commercial funding at scale has proved difficult. Companies are reluctant to pay program costs upfront (market shortcomings) because until they participate, the specific benefits to their business remain hypothetical and cannot be guaranteed. For example, when government investment in NISP® UK ended, more than a decade of incredibly significant demonstrated benefits was still not sufficient to give businesses enough comfort to pay membership or participation fees upfront into the program. In theory, initial government funding could be replaced over time as successful companies funnel a portion of their economic savings back into the program. This model has yet to be fully developed or deployed anywhere. Also, in theory, facilitated industrial symbiosis programs deliver environmental benefits that align with carbon or sustainable bond programs, but this model has not yet been developed or deployed. Therefore, **government investment in facilitated industrial symbiosis is crucial.**

One of the most important considerations for investment in facilitated industrial symbiosis programs is that the investment be committed for **multi-year** time periods to provide enough time for facilitators to follow up with businesses and to provide support for industrial symbiosis projects requiring longer timelines. For example, an industrial symbiosis opportunity that requires some initial research (e.g., to develop a method to remove contaminants from a waste stream), must work its way through R&D, then piloting and commercialization. Industrial symbiosis opportunities involving utilities or infrastructure often require many years to implement. Companies will not consider this type of synergy if they know the support will be gone in a year.

Ultimately, an investment in facilitated industrial symbiosis should support statewide coverage via **multiple regions**. The size of a region generally reflects the distance facilitators can reasonably travel for site visits, and the distance businesses can reasonably travel to attend matchmaking events. Political, cultural, economic, and bioregional boundaries must also be considered.

Estimating Investment Required: Basic Program Resources

Hypothetically, consider a centrally coordinated, facilitated industrial symbiosis program delivered across six regions. Each region should have at least one full-time equivalent (FTE) facilitator, with populous regions such as central Puget Sound having additional facilitators. The more facilitators, the more industrial symbiosis opportunities they can shepherd to completion each year. Facilitators should be professionals with industry experience and relationships and a high level of comfort with relevant technical subject matter. Facilitators should also be skilled relationship builders and able to deliver presentations and “cold calls”. In keeping with the level of professionalism and experience required, it is important that financial resources allow for facilitators to have competitive remuneration packages. Regional facilitators should also have substantial travel budgets, as they need to visit businesses around the region.



An advantage of having facilitators based in each region is that they could assist each other with delivery of workshops without calling on outside organizations. Further, annual inter-regional conferences could be delivered where learning could be shared, cross-regional barrier solutions identified, and the latest international feedback could be delivered. The conferences could be organized by the overall program coordinator organization.

In addition, sector-specific facilitators could provide support to every region. For example, a clean energy sector facilitator could work specifically to advance industrial symbiosis projects where one or more business is from that sector. Sector-specific facilitators would require adequate travel budgets.

Based on the NISP® Canada pilot and NISP® model adaptation globally, each region requires about 0.8 FTE in program support, including communications and outreach, accounting and financial controls, senior technical advisor, and overall program management, in addition to the dedicated, full-time regional facilitators. There is an economy of scale for this support layer up to about three or four facilitators.

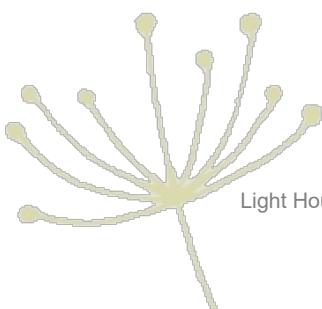
For example, a statewide, facilitated industrial symbiosis program in which the state comprises six regions could require sufficient financial resources to cover:

- Overall program director who coordinates regional delivery, reports to region-specific, state, and federal level funders, organizes any regular gathering of regional program staff, and manages any contracts for symbiosis databases and intellectual property.
- Six to eight regional facilitators
- Two sector facilitators (e.g., clean energy, integrated utilities)
- Four to seven professional support staff (communications, accounting, data analysis)
- Regional and inter-regional travel
- Overhead for the above professionals
- Venue and catering costs for ~15 to 20 matchmaking workshops per year and an annual inter-region knowledge exchange event

In addition, there will be up-front training costs, and program and software purchase or license fees associated with models such as NISP® or Materials Marketplace™.

Of course, regional delivery could be rolled out over a number of years, meaning program investment could ramp up over a number of years.

Worldwide, local and national governments are often co-investors in facilitated industrial symbiosis programs as well. Within Washington state, this could mean that in a “Seattle-Tacoma” region organizations such as King County, City of Seattle, City of Tacoma, Seattle Public Utilities, and EnviroStarsSM could be strong supporting, even funding, partners.



Connecting Facilitated Industrial Symbiosis to Materials Inventories

Facilitated industrial symbiosis programs can help to rapidly create resource inventories by drawing out information from hundreds of companies in a single year, which is generally more than the number of businesses reached via surveys and other research methods designed to generate waste resource inventories. For example, the NISP® Canada pilot identified more than six million tons of bio-based resources across just two metropolitan regions – not even across multiple regions such as an entire state or province. This data can be fed into longer-term, capital-intensive industrial symbiosis projects that are designed to utilize aggregated waste streams, such as bioenergy plants.

Performance can be boosted for passive materials exchange programs by linking them to a facilitated industrial symbiosis program, especially via data transfer. For example, business and waste information could be fed into ICT platforms such as SYNERGie®, allowing program facilitators to identify potential matches and then reach out to prospective businesses to shepherd implementation. Again, without this facilitation layer, most businesses do not have the time or resources to pursue implementation, even when there is a good business case.

Ultimately, smooth electronic data exchange is required. Connecting the database to public resource and waste datasets further increases the power of these databases. Similarly, as the facilitated programs gather more data over time, the supporting ICT becomes a more powerful tool to identify further synergies. The need for ICT platforms as part of a statewide industrial symbiosis program is discussed further under Recommendation 6 in this section.

2. Invest in RD&D to Support Industrial Symbiosis

As seen in the case studies, RD&D support can help to advance industrial symbiosis in a number of ways, such as:

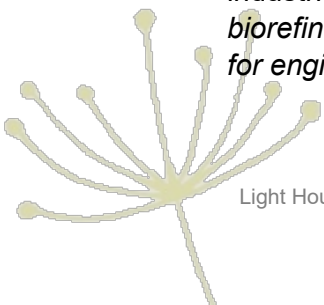
- Product development (*What else can I do with this waste material?*)
- Technology transfer (*How can the technologies enabling waste-to-energy conversion, waste sorting, etc. utilized in Denmark be adapted in Washington?*)
- Feasibility studies / business plan development (*How can my utility re-structure to be better integrated, or is there actually enough of waste X available economically to support my new business?*)
- Reducing learning-curve risk associated with the deployment of innovative industrial symbiosis (*I'm building the first biorefinery, and it might cost a bit more for engineering than a regular plant.*)

RD&D in NISP® UK

Betts in the West Midlands recovers silver from hospital X-rays. However, the hospitals changed technology, so Betts could no longer extract the silver.

The West Midlands NISP® Facilitator connected Betts to a free, five-day assistance program at Birmingham University, which found an alternative extraction process that Betts then implemented, allowing the symbiosis to continue bridging the feasibility gap to drive innovation.

i.e., "My business will benefit from implementing this industrial symbiosis match identified by my regional industrial symbiosis facilitator, and other businesses in my sector might be able to replicate the project, but the payback is a bit too long."



RD&D programs can also be used to advance industrial symbiosis involving specific sectors or solutions, e.g., clean energy, utilities and infrastructure. RD&D programs complement facilitated industrial symbiosis programs by helping businesses develop and deploy new clean technologies needed to implement an industrial symbiosis opportunity, e.g., processes to separate contaminants to make a waste reusable or to develop new products specific to an unmatched waste stream. This requires longer term funding (e.g., NISP® UK, Northern Ireland, South Africa) so that companies will engage with innovative industrial symbiosis, knowing that both the facilitated industrial symbiosis program and related RD&D support will be around for the duration of the project.

Industrial Symbiosis RD&D Facilitators could be deployed in each region to work with regional facilitators (or a few could be active serving multiple regions). This is a great role for the industry liaison offices at research institutions, perhaps as an in-kind contribution to a program. Industrial Symbiosis RD&D facilitators could also be housed within a state department, such as Commerce, Natural Resources, or Ecology. Or, contracted Industrial Symbiosis RD&D facilitators could be resourced as per the Facilitated Industrial Symbiosis Program outlined in the previous recommendation. Industrial Symbiosis RD&D facilitators could also help to deliver grant programs by raising awareness, providing guidance, brokering relationships, and so on.

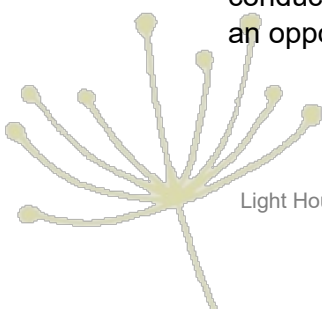
In the short-term, we recommend that Washington **establish a broad Industrial Symbiosis RD&D grant program** to support the foundation for industrial symbiosis already emerging in the state. The Circulate Industrial Ecology (Australia) grant program is a great example, and has application guides and templates that could be used as a starting point.

An Industrial Symbiosis RD&D grant program could support:

- Existing industrial symbiosis efforts involving private sector organizations, e.g., use of McKinley Paper waste heat to grow algae or to utilize agriculture or agriculture value chain wastes.
- New (and specific) industrial symbiosis opportunities involving private or public sector organizations. These projects may arise from the delivery of facilitated industrial symbiosis programs, conceptual work completed by public utilities to redirect their wastes to productive use, or from existing inventories or project concepts involving specific bio-based wastes converted to RNG. For example, in NISP® Canada, a major eco-cosmetics company is conducting research to see if it can develop a new product line from pine pollen waste, an opportunity that emerged during a workshop event.

“The Circulate program is designed to fund innovative, commercially-oriented industrial ecology projects that focus on the commercial and industrial (C&I) and construction and demolition (C&D) sectors in New South Wales. Circulate supports projects that will recover materials that would otherwise be sent to landfill, to instead use the mass feedstock for other commercial, industrial or construction processes.”

[Circulate Industrial Ecology Grant Program Round Three Guidelines for Applicants](#)



- Feasibility studies to evaluate potential bio-based resources (which generally require aggregation) for RNG generation.
- Feasibility studies for publicly owned utilities to evaluate business models to transform to multi-utility operations and/or for the evaluation of potential symbiosis connections with other regional businesses.

It is important that to effectively support industrial symbiosis, multi-year funding would be required due to timescales of RD&D projects. Knowing there is funding to support the implementation of very innovative industrial symbiosis opportunities can unlock more creative match-making at facilitation events.

In the short-term, Washington should also leverage other investments to simultaneously advance industrial symbiosis. For example, recent dairy digester grant programs are fostering industrial symbiosis by increasing the utilization of dairy wastes. By inserting explicit industrial symbiosis wording in future similar grant programs, the state can help create a more cohesive industrial symbiosis push. An Industrial Symbiosis RD&D facilitator could help increase uptake of such grant programs and integrate the outcomes into overall industrial symbiosis performance measurement.

Also in the short-term, the state could leverage existing organizations with multi-sectoral reach, such as Impact Washington or the network of Centers of Excellence.²⁰ Grant streams could target these organizations, encouraging them to support industrial symbiosis in their activities.

There do not appear to be any “shovel-ready” demonstration projects, but with the grant support described above, there could be within a few years. This gives the state time to secure an investment fund to support larger-scale, capital intensive projects such as utility conversions, biorefinery construction, or any larger projects identified from the Facilitated Industrial

The **Pacific Northwest Center of Excellence for Clean Energy** in Centralia provides leadership for a growing alliance of energy industry and college partners. The Center offers a range of “industrial symbiosis” opportunities to create and store energy, and to convert organic wastes into additional valuable resources. These include:

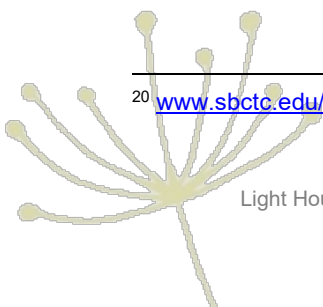
Solar: TransAlta is in the permitting process to create the largest solar project in Washington state, generating 300 jobs during construction and four permanent solar technician jobs. It’s expected to generate 180 megawatts of electricity.

Biofuel: UW completed a \$40 million feasibility study of converting poplar to biofuel; Centralia received top marks. Lewis County EDC has been in long-term talks with an international biofuel company interested in utilizing a chemical waste by-product that comes from Aberdeen.

Biochar: Conrad Industry, which previously recycled tires into gas, oil and carbon char products, is now in conversation with a major company to use its technology to create biochar and other products from wood waste.

Energy Storage: Due to the nearby Bonneville Power Administration transmission line, Centralia is strategically located as a top choice for grid-scale battery storage opportunities.

²⁰ www.sbctc.edu/for-employers/centers-of-excellence.aspx



Symbiosis Program. Such a fund could leverage contributions from private utilities or any future carbon pricing programs.

At this time, we cannot determine whether Washington should directly invest in public utilities to advance industrial symbiosis. Certainly, there is much international precedence for this, especially in the EU, but state or provincial-level utility investment is rare in North America. Many of the European projects accessed EU level funding, i.e., from their federation of states, the rough equivalent of which would be any U.S. federal program accessible by a state.

3. Establish a Policy Framework to Support Industrial Symbiosis

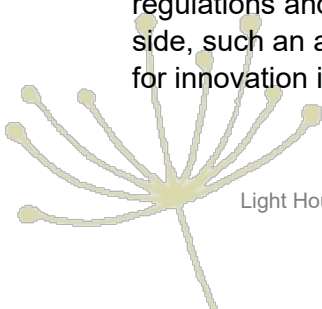
There are currently no policy or regulatory barriers to prevent the state from investing in facilitated industrial symbiosis or in a broad, responsive (rather than prescriptive) industrial symbiosis RD&D granting program.

However, while specific policy and regulation is not required to implement industrial symbiosis, it has certainly proven helpful in increasing the amount and viability of industrial symbiosis. Best practice for industrial symbiosis legislation is currently represented by the EU, which has indicated it plans to make industrial symbiosis programs mandatory in each of its member states. Its existing policies and regulations are already driving the excellent in-country industrial symbiosis work in countries such as the UK, France and Denmark. Interestingly, 12 EU countries (UK, Hungary, Romania, Belgium, Finland, France, Spain, Germany, Netherlands, Italy, Poland and Slovenia) are using or have used both the NISP[®] methodology and SYNERGie[®]. This has translated into SYNERGie[®] being chosen as the EU standard in a three-year project (establishing a Europe-wide business industrial symbiosis network) with a 95% peer review rating.

A supportive policy framework can drive innovation, ensure the participation of diverse sectors, and facilitate the involvement of publicly owned or regulated operations in industrial symbiosis. Most importantly, a supportive policy framework lays a foundation for consistent, reliable, long-term and systematic industrial symbiosis support, helping to drive paradigm change above and beyond isolated (although important and inspiring) demonstration projects.

At a high level, industrial symbiosis can be influenced by energy, industrial, economic development, environmental, water, solid waste, transportation, land use, and innovation policies and regulations. For example, the Department of Ecology's pending food waste reduction and diversion plan presents an opportunity to express explicit support for the engagement of commercial and industrial food waste generators in industrial symbiosis as well as for industrial symbiosis projects, such as bioenergy or biorefinery plants, that can utilize food wastes. Given the need for an integrated, systematic, and forward-looking policy framework, we recommend that the state **establish a cross-departmental working group** to develop any industrial symbiosis policy framework in the state.

Policy development should begin with a gap and strength analysis of existing policies, regulations and programs using an "industrial symbiosis lens." For example, on the strength side, such an analysis can help inventory and evaluate state (and federal) funding programs for innovation in energy, water and materials that could help advance industrial symbiosis, as




well as existing policy initiatives with strong opportunities for alignment and coordination with public and private sector industrial symbiosis activity. On the gap side, such an analysis can identify the need for new policies or programs. A gap and strength analysis would also help to identify opportunities where amendments alone could help to advance industrial symbiosis activity. As presented in the previous section Existing Policy Foundation, a number of elements are already in place. A gap and strength analysis can help identify how amendments or future similar policies can create more explicit support for industrial symbiosis, apply consistent language across policies, and weave policies together to create a mutually supportive matrix for industrial symbiosis.

Generally, a state industrial symbiosis policy framework should:

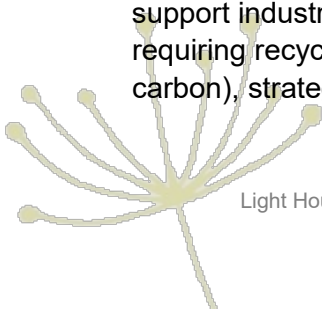
- Redefine waste as a misplaced resource.
- Clearly state an overall intent to advance industrial symbiosis in the public and private sector and in all regions.
- Require state policies and programs to align with industrial symbiosis support where possible.
- Allocate financial resources to advance industrial symbiosis (e.g., long-term support for facilitation programs, RD&D grants, other financial incentives).
- Establish intent to effectively leverage other state, federal, and private funding and investment.

Redefining waste as a misplaced resource drives waste resources back into circulation. For example, landfill bans can encourage businesses that generate banned wastes to find alternative uses.

	<p style="text-align: center;">Washington State Solid and Hazardous Waste Plan The overriding goal of the plan is “to eliminate waste and toxics wherever we can and use the remaining wastes as resources.”</p>
---	---

The UK government introduced a landfill tax with a long-term aim to incentivize companies to cease sending waste to landfill. The tax works via an annual escalator, enabling companies to predict when it becomes cost-effective to seek alternative routes, such as when an industrial symbiosis solution becomes cost-neutral or cost-beneficial compared to landfilling. As an aside, initially the escalator was used to fund resource efficiency initiatives, such as the original National Industrial Symbiosis Program (NISP®) in the UK, feeding the revenue generated by the tax back to companies in the form of targeted assistance to prevent generation of the waste in the first place. In more recent years, this tax has been used to offset corporate tax levels – thus all companies receive decreased tax requirements, while companies that then seek to remove waste from landfill receive dual benefits.

The introduction of the landfill tax in the UK is seen as the biggest financial enabler of waste recycling by the Environment Agency. Government procurement policy can be used to support industrial symbiosis by purchasing industrial symbiosis-derived materials, e.g., requiring recycled aggregate for road construction. Other policy levers include taxation (e.g., carbon), strategic collection and use of public data (who produces waste, who treats waste,



what are their licensed capabilities), extended producer responsibility or “take-back” legislation, climate change, environmental and economic development strategies, and budgeting processes that can allocate direct investment for market development, facilitation, and RD&D.

End-of-waste regulations could be used to create markets for both processing and use of transformed materials. This has proved very successful across Europe. By treating wastes with approved methods such that the end product meets required specifications, companies can use the treated wastes in their production processes without the need to apply for waste management licenses. Further, consumers of the products produced have confidence that the products are safe.

There are numerous EU documents that could provide inspirational structures and language for new policy development and amendments. For example, the European Waste Framework Directive Amendment (2018) includes high-level policy language clearly driving industrial symbiosis:

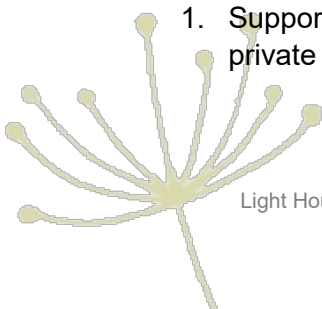
“Waste management in the [EU] should be improved and transformed into sustainable material management ... promoting the principles of the circular economy ... in a way that preserves resources and closes loops” and “... the Commission should be empowered to adopt implementing acts in order to establish detailed criteria ... prioritising replicable practices of industrial symbiosis.” – *Official Journal of the EU L150 Vol 61*

Additional potentially useful EU policy documents are listed below:

- European Waste Framework Directive (2009)
- Roadmap to Resource Efficient Europe – exemplar (2011)
- DG Regions: Connecting Smart and Sustainable Growth through Smart Specialisation – exemplar (2012)
- DG Enterprise: Communique on Green Entrepreneurship (2013)
- European Resource Efficiency Platform – short-term recommendation (2014)
- DG Innovation & Research: Short guide to assessing environmental impacts of research and innovation policy (2014) [note: citing NISP®]
- Circular Economy Package (2015)
- European Environment Agency, Circular economy in Europe (2016)
- DG Energy Strategic Energy Technology Plan (2018)
- Waste Framework Directive amendment 2018

Specifically, we recommend that state policies and programs, including those providing financing and grants, pursue the following goals:

1. Support a state-wide facilitated industrial symbiosis program inclusive of all public and private sector operations



2. Continue to advance clean energy
3. Ensure that utilities and infrastructure engage in and benefit from industrial symbiosis
4. Provide funding support for industrial symbiosis-related research, development and deployment (RD&D)
5. Support consistent and effective resource data collection

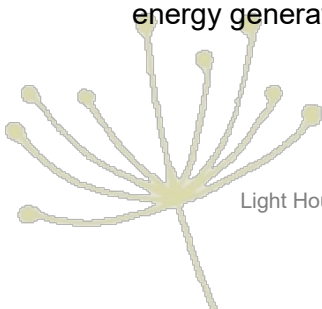
4. Continue Support for Clean Energy Sector

The clean energy sector, especially the bioeconomy, is well-positioned to advance industrial symbiosis. In turn, facilitated industrial symbiosis programs help advance clean energy. For example, the NISP® Canada pilot engaged 54 businesses working within or with the agriculture and food sector and identified more than six million tons of underutilized agriculture and food resources and hundreds of potential industrial symbiosis projects, on top of long-term diversion to bioenergy generation. Some of the “waste” bio-based resources uncovered just in the Metro Vancouver region included:

Caramel waste	Algae-derived biomass	Rice hulls, wheat or barley straw
Mushroom compost	Cannabis waste	Pollen
Cocoa powder	Spent grain	Chocolate husks
Dried grains	Coconut oil	Meat and seafood rejects
Dog waste	Poultry litter	Spent growing media
Organic waste high in fats	Spruce tips	Chocolate chips and husks
Hemp fiber	Paper waste	Flat beans
Pine pollen and husks	Recovered nutrients	Spirulina

Washington state has already achieved much success in the clean energy sector, committing to a carbon neutral electricity supply by 2030 and carbon-free supply by 2045. Increased renewable natural gas (RNG) production will rely on bio-based feedstocks. Commerce’s Dairy Digester Enhancement grant program provides funding for projects that produce bioenergy or value-added fertilizers, both of which demonstrate industrial symbiosis.

Most clean energy efforts (e.g., carbon targets and pricing) will implicitly drive industrial symbiosis activity. However, clean energy policies and programs should explicitly support industrial symbiosis where possible to maximize industrial symbiosis output (as per Recommendation 3 regarding an industrial symbiosis policy framework). Policies that support anaerobic digestion of waste bio-based materials, increase RNG generation, increase alternative vehicle fuels, and generally reduce the carbon footprint of thermal and electrical energy generation will all drive industrial symbiosis.



It is important to ensure that industrial symbiosis programs, in turn, support clean energy by:

- Considering a dedicated facilitator to support identification and implementation of industrial symbiosis involving at least one business from the bioenergy sector (see Recommendation 1, Invest in Facilitated Industrial Symbiosis, for a full description of a facilitated industrial symbiosis program).
- Driving RD&D investment to clean energy projects that also implement industrial symbiosis (see Recommendation 2, Invest in RD&D to Support Industrial Symbiosis), such as energy generation or alternative fuels that utilize waste bio-based feedstocks (including from wastewater treatment plants). State funding for a TransAlta biorefinery feasibility study is a good example.
- Leveraging publicly owned and/or regulated infrastructure and utilities to simultaneously support clean energy and integrated utility development (see Recommendation 5 regarding industrial symbiosis and integrated utilities).

“County commissioners voted Monday to assign \$120,000 to a study that will explore whether the county would be a good site for a biorefinery — a development that leaders believe would be a major boost for the area’s economy.

‘I look forward to moving on this project,’ said county commissioner Gary Stamper. ‘I’m very excited about it.’

The feasibility study will be conducted by the University of Washington at a total cost of \$600,000, the rest of which is coming from the state and a TransAlta Coal Transition grant. Richard Gustafson, a chemical engineer with the university, has led UW’s efforts on the issue.”

The Daily Chronicle
August 19, 2019

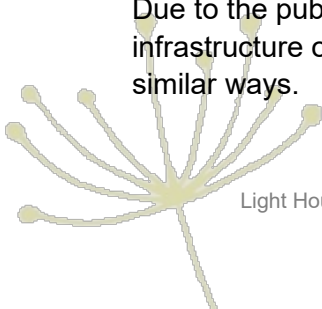
5. Drive Industrial Symbiosis in Utilities and Infrastructure

As shown in the case studies (see Appendix A), utilities such as wastewater treatment, electrical generation, and district heating and cooling facilities have high industrial symbiosis potential. As the case studies show, even greater industrial symbiosis is achieved when utility operations can be integrated, especially when district heating systems are supported. Wastewater treatment plants, for example, can be used to generate both heat and power.

With the exception of large electrical generation facilities, utility services in Washington are primarily owned, operated or contracted by local governments. Local and state government agencies are both responsible for infrastructure construction and maintenance.

While the primary role of state government is likely to be as catalyst for utility-based industrial symbiosis, there are opportunities to bring significant financial and logistical resources to play through public-private partnerships (e.g., exempt facility bonds for waste management, expedited state and local permitting).

Due to the public ownership aspect, and the large-scale, capital-intensive nature of utility and infrastructure operations, industrial symbiosis program efforts can engage these operations in similar ways.



Encourage utility and infrastructure participation in facilitated industrial symbiosis

In the short-term, the state can help utilities and infrastructure projects identify and implement industrial symbiosis by encouraging their participation in a **facilitated industrial symbiosis program** (see Recommendation 1), which can help to identify current “waste” resources generated by utilities and infrastructure operations as well as “waste” resources that utilities and infrastructure projects or operations can use, e.g., wastes that can be used as aggregate in road construction. Via NISP® Canada, Metro Vancouver identified a number of potential symbiosis matches for its operations.

The NISP® UK program catalyzed utilities to come together to coordinate their asset management activities

recognizing that resources from one phase of work could be used by another project in a different phase (see Major Infrastructure Resources Optimization Group sidebar). For example, leftover pipework and connectors may not always be returned to stock and might be disposed of at the end of a contract. Spoils and soil removed through excavation could be used as fill material at another project, either directly in holes or in the construction of temporary roads. The SYNERGie® database enables these resources to be transferred directly to a new project.

“Instead of solely collecting and transporting wastewaters as far downstream as possible to central treatment plants where wastes are cleansed to meet permit limits prior to discharge to waterways, the Utility of the Future transforms itself into a manager of valuable resources, a partner in local economic development, and a member of the watershed community seeking to deliver maximum environmental benefits at the least cost to society.

It does this by reclaiming and reusing water, extracting and finding commercial uses for nutrients and other constituents, capturing waste heat and latent energy in biosolids and liquid streams, generating renewable energy using its land and other horizontal assets, and using green infrastructure to manage stormwater but also to improve urban quality of life more broadly.

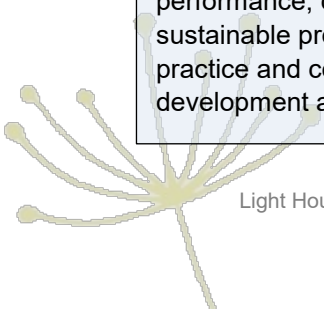
These actions benefit the utility in the form of reduced costs and increased revenues. But they also deliver environmental, economic, and social benefits both locally and nationally.”

[The Water Resources Utility of the Future ... A Blueprint for Action](#)

National Association of Clean Water Agencies (NACWA), Water Environment Research Foundation (WERF), and Water Environment Federation (WEF). 2013.

AECOM and International Synergies Limited founded the [Major Infrastructure–Resources Optimisation Group](#) (MI-ROG) in 2013 as a forum for the UK’s infrastructure operators to collaborate across the circular economy theme and to meet the challenge of delivering major infrastructure in a constrained economy.

“MI-ROG members are senior representatives of Anglian Water, Centrica, EDF Energy, the Environment Agency, Heathrow Airport, Highways England, HS2, National Grid, Network Rail, Thames Tideway Tunnel and United Utilities. The first forum of its kind in the infrastructure sector, with AECOM chairing, MI-ROG has inspired and facilitated workflows on asset life cycle, carbon performance, circular economy planning, critical materials availability, materials exchange and sustainable procurement and supply chains. The group benchmarks approaches, shares best practice and collaborates across projects, seeking greater resilience and efficiencies with planning, development and delivery of major programs.”



Invest in a dedicated Utilities & Infrastructure Industrial Symbiosis Facilitator

A dedicated **utilities and infrastructure industrial symbiosis facilitator** can increase public sector participation in facilitated industrial symbiosis and provide implementation support for opportunities involving at least one utility operation or infrastructure project. Such a person could also help coordinate similar symbiosis efforts across the state, and could also act as a conduit to transfer knowledge from region to region. Organizations such as the Washington Public Utility Districts Association, as well as investor-owned private utilities, might be able to co-fund this position.

Target RD&D grants to advance industrial symbiosis involving utilities and infrastructure

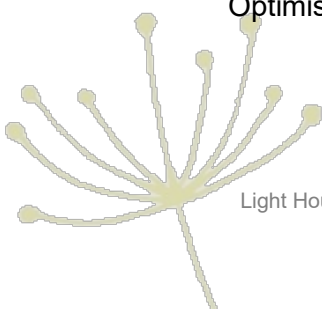
The continued transformation of utility operations to integrated utility complexes, or the construction of new utility complexes, will require significant capital-intensive efforts. These larger efforts are likely to be primarily self-organized (see the Metro Vancouver, Fors A/S Municipal Integrated Utility, and Solrod A/S Biogas Plant case studies).

In addition to grants supporting technical research, e.g., evaluation of uses for biosolids, grants could support innovative, integrated design process (IDP) and industrial symbiosis opportunity assessments during utility and infrastructure design. The design phase has the greatest opportunity to deliver industrial symbiosis for utilities and infrastructure. We know that an IDP achieves better buildings; the same holds true for utility and infrastructure design.

Grants could also help private and public utilities develop business models and undertake structural and operational changes to create more integrated utilities.

Other actions to encourage industrial symbiosis involving utilities and infrastructure

- Enact procurement policies that require (or at least strongly encourage) the use of recycled materials, especially those representing resources recovered regionally, as well as consideration of industrial symbiosis opportunities during utility and infrastructure design.
- Leverage utility permit processes (e.g., Department of Ecology's permits for the 600 WWTPs in the state) and environmental assessments required under the State Environmental Policy Act) to drive participation in facilitated industrial symbiosis and the completion of studies evaluating industrial symbiosis potential.
- Develop a "green bond" program, including municipal bonds, specifically supporting utility-driven industrial symbiosis, especially involving WWTPs.
- Provide financial and other support to foster sector collaboration and knowledge exchange, e.g., organizations similar to the UK's Major Infrastructure - Resources Optimisation Group.



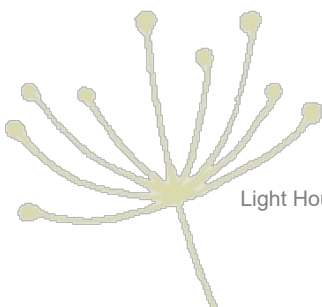
6. Consolidate Data Management and Performance Reporting

Most materials flow database tools are inseparable from passive waste exchange programs and suffer from the same problems such as lack of specificity, being out of date, requiring a lot of effort from users, and hosting few resources. As the case studies demonstrate, while materials flow database tools do foster some industrial symbiosis, it is not to the scale or diversity of facilitated industrial symbiosis. Investment in the “right” proactive platform aligned with facilitated industrial symbiosis is likely to bring greater return across economic, environmental and social parameters than investment in materials exchange tools.

We must, however, recognize that multiple ICT platforms will likely continue to be in play. King County IMEX is likely to continue as it is long-standing and has had some success. Data entered here could be transferred or shared through bulk upload or an API to the Facilitated Industrial Symbiosis Program, and facilitators can seek and support additional opportunities. The concept of a materials exchange database is intuitive, so support can be hard to shake even in the face of multiple reviews showing their relatively lower performance. There will likely be continued materials exchange databases on the market. In addition, some industries have waste tracking software, e.g., LEED® compliant Green Halo Systems for tracking construction waste, with data that could support facilitated industrial symbiosis.

The [Major Infrastructure - Resource Optimisation Group](#) (UK) tabled several ways in which projects can incorporate and advance the circular economy, which includes industrial symbiosis:

- Provide examples integrating circular economy principles, such as: (1) keeping resources in use for as long as possible, (2) extracting the maximum value from resources while in use, (3) recovering and regenerating products and materials at the end of life, and (4) keeping products, components and materials at their highest utility and value at all times.
- Highlight how solutions were identified and benefits were quantified.
- Demonstrate how your design will encompass the circular economy, giving examples of your choice of construction materials and processes and quantifying the total benefits compared to a standard approach. This should include: (1) maximising retention/reuse of existing assets, (2) minimising the use of non-renewable primary materials, (3) reducing waste-ensuring longevity, and (4) maximising the value of materials once the original purpose is accomplished.
- Demonstrate how your product/material will contribute to the circular economy, through: (1) offering a service model, (2) providing a take-back scheme, (3) ensuring recyclability which retains value, (4) offering enhanced recycled content, (5) minimising packaging and using recycled, recyclable or compostable packaging, and (6) minimising the use of non-renewable primary materials, reduced waste, and maximising the value of the materials when no longer required.



Database Selection

Ideally, a materials flow database used as part of an industrial symbiosis program should:

- Have user-friendly, multiple points of data entry²¹ (e.g., uploading public datasets, integration with other platforms, “self-serve” entry), ideally with a common reporting mechanism.
- Support identification of industrial symbiosis opportunities.
- Facilitate and track implementation, including tracking barriers and efforts to overcome them as well as progression of implementation.
- Support environmental and economic performance measurement.
- Have analytical and reporting-out capabilities to serve private and public sector needs.

We could not find any tools previously used at government levels to help track material resource flows and report out on industrial symbiosis metrics (see Table 1). SYNERGie[®] has recently been selected as the European standard²² and is being expanded for that use. We do believe that SYNERGie[®] currently best meets the goals listed above.

We also recommend support for efforts to generate and upload data in usable forms to integrate with overall industrial symbiosis efforts. An example would be to create connections between data, e.g., excess land and facility space uncovered via facilitated industrial symbiosis should feed into Startup Washington’s Property Search portal²³, or Department of Ecology permit data. The establishment of a public database of producers, carriers and treatment companies, together with licensed versus actual volumes could form the basis of an industrial symbiosis dataset. The UK is consulting with industry to establish a mandatory reporting system to support such a data provision.

Establishing Metrics

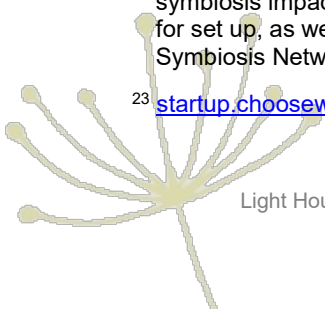
Any state investment in industrial symbiosis should be tied to performance metrics. At its core, industrial symbiosis seeks to transform waste into value-added production. Metrics related to this include:

- Waste diverted from landfills
- Virgin materials displaced
- New sales revenues

²¹ There is little to no point in resource inventories that are only ‘on paper’ as data in such cases cannot be shared across multiple actors and no proactive analysis is possible.

²² The Pan European Industrial Symbiosis Business Network (Cir@Lean) was announced in September 2019 by the EU DG Grow. It seeks to elaborate and endorse a voluntary common approach for the reporting of industrial symbiosis impact and to monitor the uptake of this approach by businesses. The contractor will be responsible for set up, as well as the technical and administrative secretariat, of an industry-led Europe-wide Industrial Symbiosis Network. The core ICT tool supporting the network will be SYNERGie[®].

²³ startup.choosewashingtonstate.com/tools/property-search

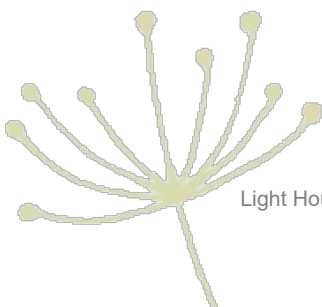



- Reduced operating costs
- Greenhouse gas emissions saved and avoided

Most of these metrics require working with participating businesses to collect and verify data, even where software allows for businesses to enter such data themselves. As part of the new European Business Industrial Symbiosis Network a standard on metrics will be developed using the CEN Workshop Agreement mechanism and should be available by 2021.

In addition, programs can track how much value is added by examining how many steps up the waste management hierarchy a material flow has progressed. “Participation” metrics, e.g., number of businesses engaged or number of resources identified, can also be helpful. Where funding is tied to specific sectoral or geographic interests, metrics can be sub-reported as required, e.g., the BC Ministry of Agriculture required NISP® Canada to report on the number of agriculture value chain participants. In addition, direct job creation can be tracked and/or modelled by building state multipliers into the database.

Metrics should not be too narrow so that certain sectors or resources are excluded. Generally, limiting metrics to particular sectors or materials is the antithesis of what industrial symbiosis is all about. A wide scope increases the level of opportunity, is more inclusive, and at any point during a program gap analysis can be undertaken to identify (and thus target) key missing sectors that would enhance the industrial symbiosis offering and impact.





Washington Industrial Waste Coordination (Industrial Symbiosis)

Program Recommendations

Appendix A: Case Studies

NOVEMBER 2019

LIGHT HOUSE SOCIETY

**with International Synergies Ltd.
and Center for Sustainable
Infrastructure**

PREPARED FOR

**Washington State Department of
Commerce**



Appendix A: Key Case Studies

The following case studies were compiled drawing on publicly available information, except where noted. In addition, the case studies for projects in Denmark were supported by site visits conducted by CSI staff during September 2019.

Taken together, the case studies underscore the potential for utility and bioenergy/biorefinery operations to facilitate numerous industrial symbiosis flows, especially when combined with municipal solid waste flows such as aggregated residential plastics or organics.

In particular, the existence of multi-utilities with an ability to integrate water, wastewater, energy, and solid waste services under one (generally public and non-profit) corporate umbrella is helpful. RD&D support has been vital in advancing industrial symbiosis for these types of projects as well. These projects are large, capital-intensive and self-organized, with some facilitation support. Case studies in this category include:

Self-organized
1. Kalundborg, Denmark
2. Billund Biorefinery, Denmark
3. Solrod A/S Biogas Plant, Denmark
4. Fors A/S Municipal Integrated Utility, Denmark
5. Metro Vancouver Integrated Resource Recovery, Canada

Programs with a heavy facilitation component also succeed in capturing significant regional waste material flows for industrial symbiosis, especially from the private sector. These facilitated industrial symbiosis programs generally require operational funding from government sources, but not to the level of RD&D and capital required for utility and biorefinery operations. Facilitated symbiosis can feed RD&D by engaging regional institutions in applied research related to unique, regional private waste material flows uncovered by facilitated industrial symbiosis. Case studies in this category include:

Facilitated
6. National Industrial Symbiosis Programme (NISP®) UK
7. NISP® Canada
8. The (Invest NI) Industrial Symbiosis Service

We completed a preliminary review of waste exchanges, including the Materials Marketplace programs, but the reported solid waste diversion numbers were relatively low (~841 tons per year for Ohio Materials Marketplace, ~391 tons per year for Tennessee Materials Marketplace, ~106 tons per year for Austin Materials Marketplace) except for SWIX.

This is consistent with international findings – uptake with waste exchanges tends to be low, as does implementation, due to the reliance on businesses finding each other and building a personal and commercial relationship, especially for symbiosis versus exchanges that simply help connect a business to a waste hauler. We have included one waste exchange.

Waste Exchange

9. Southern Waste Information Exchange, Florida

Lastly, the RD&D push for industrial symbiosis and pull from industrial symbiosis efforts can be seen in most of the case studies present. Often, this is supported by government granting programs tangential to industrial symbiosis, e.g., for waste-to-energy capital costs. However, one state in Australia runs the Circulate Industrial Ecology Program for RD&D, specifically providing grants for industrial symbiosis projects:

Symbiosis Project Fund

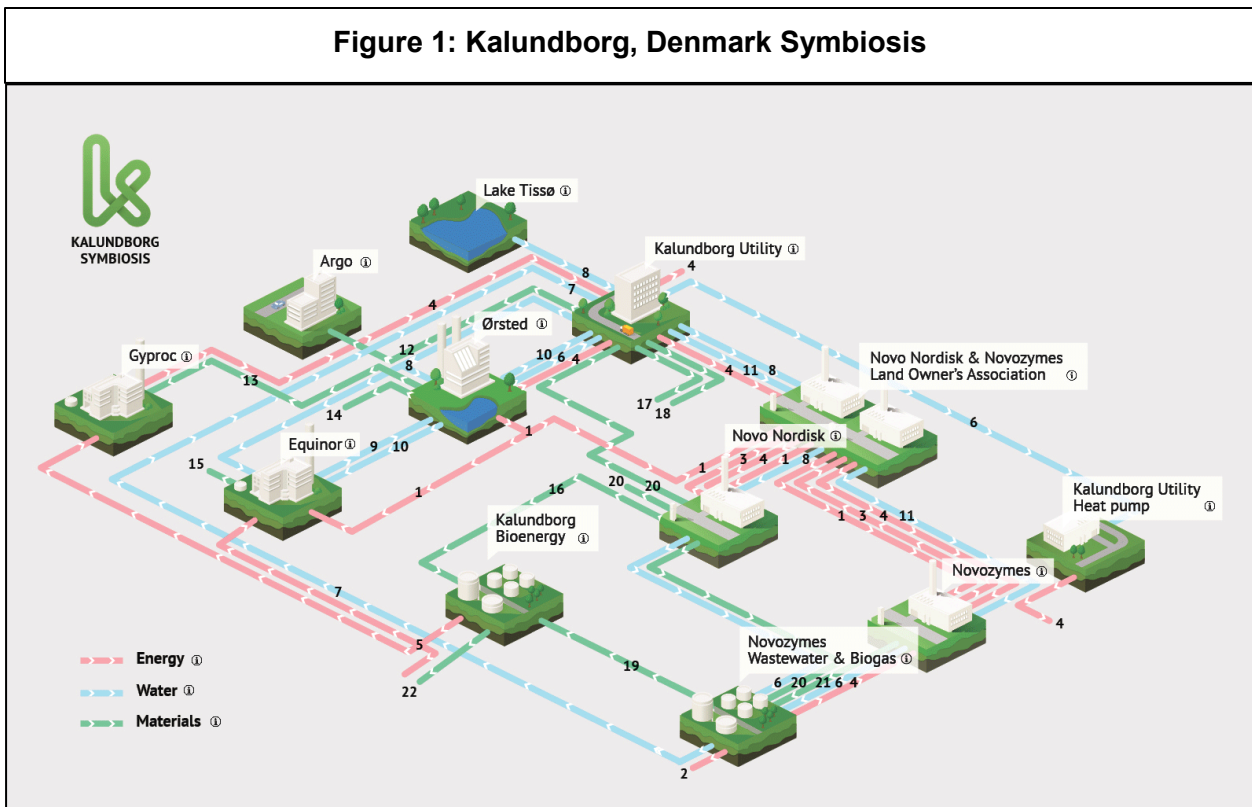
10. Circulate Industrial Ecology Program, New South Wales, Australia
--

Kalundborg, Denmark

Kalundborg Symbiosis is a resource partnership between six private companies, with 11 production sites, and three public operators. Kalundborg is considered the world's leading pioneer of the industrial symbiosis concept. It began as a self-organized collaboration of several private companies, with municipal involvement gradually growing over the decades. The businesses involved include a power plant, the world's largest enzyme manufacturer, Denmark's largest crude oil refinery, and a municipally owned multi-utility:

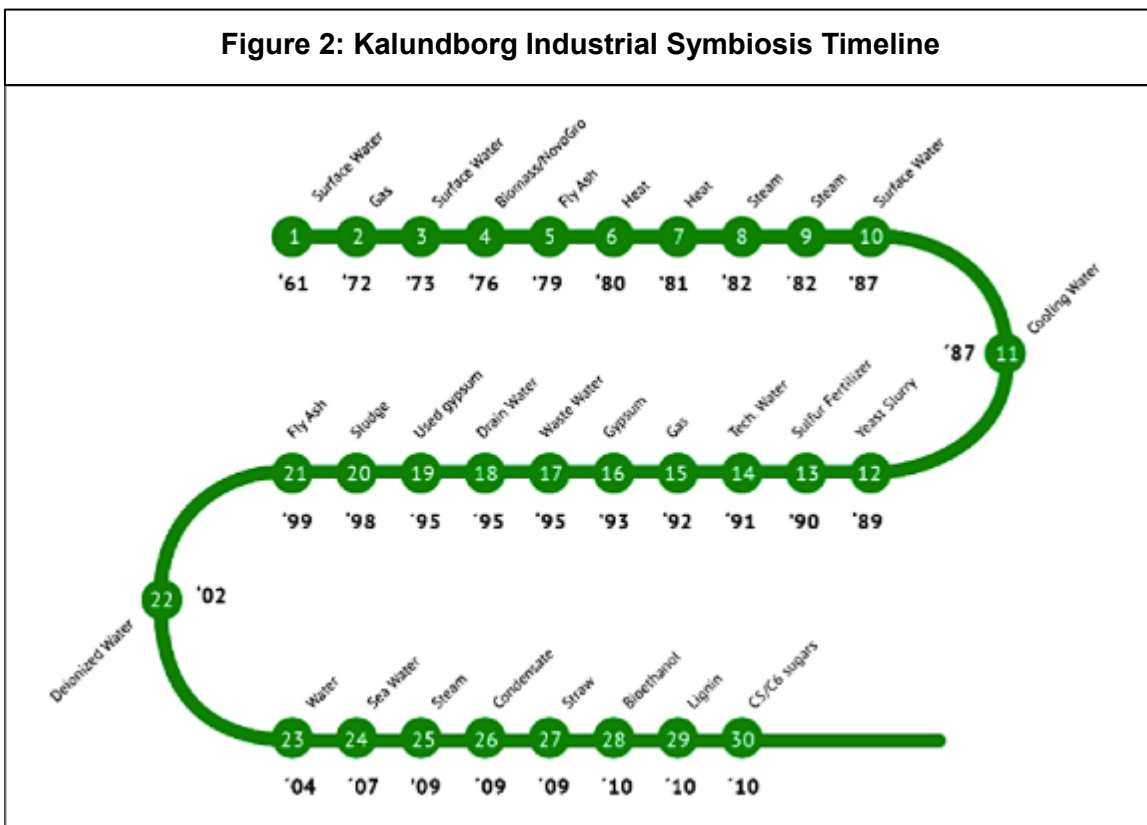
- Equinor Refinery, Denmark's largest oil refinery.
- Orsted Power Plant, which started as a coal-fired power plant but, in 2017, began a two-year transition to a bioenergy (wood and other biomass) plant. Orsted supplies district heating and grid electricity.
- Kalundborg Biorefinery, which generates bioethanol, biomass pellets, and biogas.
- Novo Nordisk and Novozymes, the world's largest enzyme manufacturing facility.
- Gyproc, a gypsum board manufacturing plant.
- Kalundborg Utility, a municipally owned, non-profit multi-utility serving 50,000 customers (drinking and process water treatment and distribution, cooling water distribution, wastewater collection and treatment, district heating). The multi-utility operations are critical to the symbiosis flows, and the company actively seeks to foster industrial symbiosis, even investing in projects such as the plant's transition from coal to biomass.
- Argo, a waste management and recycling company jointly owned by nine municipalities.

Figure 1: Kalundborg, Denmark Symbiosis



The companies have clearly benefitted and are committed to continually advancing resource sharing. Their 22 symbiosis flows evolved over 40 years, as shown in Figure 2. Utility operations are integral to many of the flows, including the presence of a district heating system which creates local demand for waste heat. For example:

- Biogas from the WWTP is used to produce heat for the district energy system and electricity for the national grid.
- Residual biomass from local industrial and agriculture waste is used to produce RNG by upgrading biogas.
- A sewer heat recovery system (like the one in Vancouver, BC's Olympic Village) uses heat pumps to extract heat for the district energy system from cleaned wastewater.



Source: Corporate Eco Forum 2016

The Kalundborg Institute was launched in 1996 to facilitate additional and more complex industrial symbiosis relationships, and to support education and outreach. In 2015 it was replaced by Symbiosis Centre Denmark.

Kalundborg also catalysed much RD&D, including the launch of BioPro, a biotech research center formed by CP Kelco, DONG Energy, Novo Nordisk, Novozymes, Technical University of Denmark, and University of Copenhagen, with funding from the state government (Region Zealand), the EU, and the partners themselves, with management contracted to the private firm CAT. Kalundborg Utility is setting up a campus-like environment by collaborating with the local education institution's engineering program, which specializes in biotechnology. The

utility is working to attract masters' and PhD-students together with interns from a wide range of educational backgrounds.

In addition to the Kalundborg Utility, Novo Nordisk has been a key driver in identifying and implementing industrial symbiosis. Pharmaceutical production is a resource-intensive process, requiring a great deal of water and energy. Despite this, Novo Nordisk will be completely powered by renewable electricity by 2020 and hopes to achieve zero carbon emissions by 2030. In 2004, Novo Nordisk carbon emissions and water consumption were increasing proportionally with its revenues. Novo initiated a partnership with Dong Energy (now Orsted), experts in energy and the operator of the Asnæs Power Station, to determine how they could grow sales while reducing their energy consumption and GHG emissions. Dong reviewed Novo Nordisk's production process to find savings. In return, Novo reinvested the money saved in Dong's next venture – windmills – and began buying wind power from Dong. They also tinkered with other production process improvements, including their yeast strains, to produce more product per liter of water input, reducing their use of resource inputs of energy and water.

Michael Hallgren, senior vice president at Novo Nordisk Kalundborg says, "We have decoupled our resource consumption from our sales. First of all, sales increased while CO2 emissions remained flat. Then we made a commitment in 2006 to reduce CO2 emissions to 10 percent below what we emitted in 2004. Emissions remained flat while sales grew until 2007 when the emissions began to decline." As sales continue to increase, the company must work ever harder to find ways to reduce emissions.

Kalundborg Summary

Organizational Structure	Program Category
Private corporations + municipally-owned utility	Self-organized
Funding Source	Budget
Mainly private, with significant municipal, national and EU support, e.g., the biorefinery received \$11.4 million from the Danish Energy Authority.	n/a (many multi-million dollar expenditures over the years, e.g., the biorefinery plant's initial phase cost \$60 million)

Status	Start Date	End Date
Ongoing	1972	n/a

Program Outcomes

Solid Waste Diverted	N/A overall. Kalundborg Biorefinery was reported to consume 30,000 tons of waste wheat straw in 2009.
GHG Emissions Avoided	635,000 tons CO ₂ based on life-cycle assessment (equivalent to footprint of 37,000 Danes)
Economic Benefits	€14M socioeconomic €24 business economic Utility Profitability: annual spend DKK203M; annual revenue DKK314M
# Symbioses / Businesses	22 symbiosis flows involving six companies over 11 sites

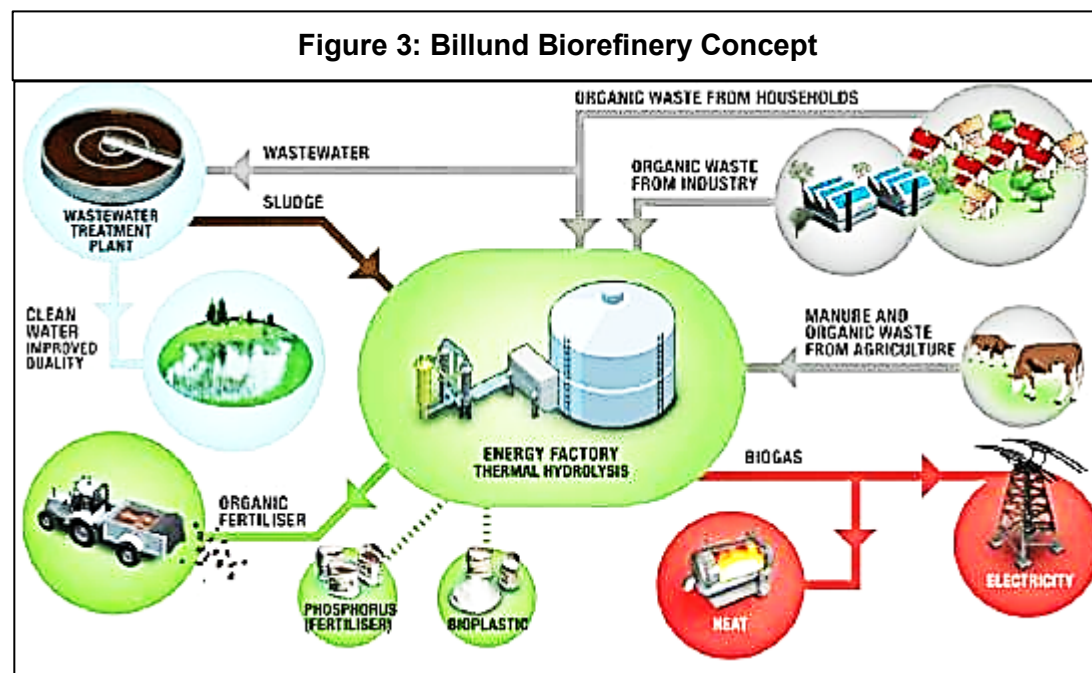
Program Contact

Lead Organization	Contact
Symbiosis Center Denmark	Thomas Nielsen, Senior Project Manager
symbiosecenter.dk/en	Thomas.Nielsen@kalundborg.dk

Billund Biorefinery, Denmark

The Billund Biorefinery is part of a private-public partnership between Billund Vand, the municipality of Billund's public utility, and Krüger. Billund Vand, or Billund Water & Energy as it's known in English, includes four companies: Billund Drinking Water, Billund Energy, Billund Wastewater, and Billund BioRefinery.

Billund BioRefinery combines several unique technologies, reducing energy required for wastewater treatment while producing treated wastewater that exceeds Danish standards. The BioRefinery also recovers more energy from wastewater and waste, and produces sludge, which can be refined to produce an odorless organic fertilizer. The BioRefinery accepts wastewater from the municipal sewer system as well as from the local DuPont plant, which saves DuPont \$2 million per year in treatment costs.



Source: Nielsen, P.H. *Microbial biotechnology and circular economy in wastewater treatment*. *Microbial Biotechnology* 10(5) · August 2017. [Figure 1](#) licensed under Creative Commons.

The BioRefinery also consumes organic household and industrial waste to produce energy. "98% of all wastewater and household waste sorted at source is now recycled at Billund which is totally unique at international level – and creates a whole new outlook on wastewater and waste as valuable resources."¹

In addition to managing water supply and wastewater treatment for the municipality, the Billund Biorefinery generates value to the local economy by:

¹ www.billundbiorefinery.dk/en/news/item/fyrtarnet-billund-biorefinery-viser-vejen-frem-for-miljo-og-eksport

- Treating organic wastes from households and local industry.
- Treating the organic fraction of the municipal solid waste stream.
- Producing energy (both heat for the local district system and electricity for the power grid).
- Producing valuable products from waste streams, including highly clean fertilizer products.
- Developing strong collaborations with local industry.

The BioRefinery undertakes continuous R&D tests of new processes and products to better optimize value generation from inputs. For example, the BioRefinery is working with LEGO® global headquarters in Billund to test bioplastic polymer production and is also trialing pyrolysis-to-polymer/biochar production pathways.

The BioRefinery was awarded Svend Auken's Environmental Prize, the European Business Award, and Global Water Awards.

Billund Summary

Organizational structure	Program Category
Joint venture between private corporation and municipal utility	Self-organized (Technical / Engineering)
Funding Source	Budget
Local taxes, energy sales, and a grant from the Danish Eco-Innovation Program	Capital cost \$12 million

Status	Start Date	End Date
Ongoing	2009	n/a

Program Outcomes

Solid Waste Diverted	5,000 tons per year dry sludge
GHG Emissions Avoided	27,000 MWh per year of biogas
Economic Benefits	Reduced costs: \$800,000 per year to municipal water and wastewater system Increased sales: \$1.5 million per year from green energy
Other Benefits	Manure management for local farms Increased treated wastewater discharge quality Creation of new nutritive organic fertilizer
# Businesses / Synergies	< 10 (+1,600 households)

Program Contact

Lead Organization	Contact
Billund Vand & Energi	Ole Johnson, CEO
www.billundbiorefinery.dk/en www.billundvand.dk stateofgreen.com/en/partners/billund-biorefinery/solutions/billund-biorefinery-1	opj@billundvand.dk

Solrod A/S Biogas Plant, Denmark

The Solrod Biogas plant was developed as a means for the Municipality of Solrod to reduce greenhouse gas emissions as per its Sustainable Energy Action Plan. The plant is municipally (publicly) owned and transforms 190,000 tons per year of biobased wastes into heat, electricity and agricultural fertilizer. The primary feedstocks are lemon-derived pectin and carrageenan from CPKelco, eluate (biotech waste from lactic acid production) from ChrHansen, as well as biopulp, manure from local livestock farmers, and seaweed overload from local beaches.

By accepting seaweed overload, the biogas plant is helping to reduce aquatic pollution, where nutrient load in Køge Bay is a major problem, and reduce odors. The plant also reduces nitrogen and phosphor loading in Køge Bay.

Photo 1: Solrod Biogas A/S Plant



Source: bigadan.com/c/cases/solroed-biogas

Solrod Summary

Organizational Structure	Program Category
PPP between education, municipalities and industries	Self-organized (Technical)
Funding Source	Budget
Capital: Conventional financing flowed through municipality, \$600,000 grant from EU agency in design phase. Operational: taxes, heat, electricity and fertilizer sales (Solrod Biogas Ltd. associated private company selling gas)	Capital cost \$12.6 million

Status	Start Date	End Date
Ongoing	2009	n/a

Program Outcomes

Solid Waste Diverted	190,000 tons per year biosolids
GHG Emissions Avoided	46,000 tons in 2018 (28% of municipality's emissions)
Economic Benefits	~\$5 million in sales revenues in 2018, 15 FTE jobs
Other Benefits	Generation of 55 GWh per year of renewable energy from sustainable sources Reduced aquatic pollution, especially nutrient loads, e.g., 120 tons per year of nitrogen and nine tons per year of phosphorus

Program Contact

Lead Organization	Contact
Solrod Biogas	Mikkel Busck, Project Manager
solrodbiogas.dk	mbu@solrod.dk

Fors A/S Municipal Integrated Utility, Denmark

Fors is a public, non-profit multi-utility company responsible for potable water, district heating, wastewater, and waste and recycling services for about 190,000 customers in Denmark's Holbæk, Lejre and Roskilde Municipalities. Shares in Fors A/S are owned by the municipalities of Holbæk, Lejre and Roskilde.

Fors actively supports a local business networking forum, which has leveraged industrial symbiosis relationships by uncovering partnerships with businesses on projects with a strong business case for both the business and the utility. They have formed value-generating partnerships with a variety of local businesses and industry, resulting in new industrial symbiosis, including:

- Recycling rooftop filling waste (tarpaper) from Fors into asphalt at another firm.
- Replacing gravel with recycled polystyrene from Fors' waste collection for Galaxe Gluve's lightweight concrete. Galaxe Gluve now retrieves the polystyrene at no cost to Fors.
- Recycling discarded plastic from Fors' new plastic collection bins.
- Recovering excess heat from a liver pate manufacturer for use by the local district heating system.
- Delivering sewer heat recovered by the utility to its district heating system.

Fors A/S Summary

Organizational structure	Program Category
Public multi-utility jointly owned by 3 municipalities	Self-organized (Technical) plus limited facilitation
Funding Source	Budget
Collection fees, taxes, local government funding	n/a

Status	Start Date	End Date
Ongoing	n/a	n/a

Program Outcomes

Solid Waste Diverted	n/a
GHG Emissions Avoided	n/a (but 4,000 MWh associated with recovered heat from liver pate manufacturer)
Economic Benefits	~\$6.7 million per year (\$135 million over 20 years for sewer heat recovery) \$109 per ton saved by Fors not having to transport waste polystyrene

Program Contact

Lead Organization	Contact
Fors A/S	Lærke Ærenlund, Innovation Manager
stateofgreen.com/en/partners/fors www.fors.dk	lae@fors.dk

Metro Vancouver Integrated Resource Recovery, Canada

Metro Vancouver is a regulated Regional District, established by the province of British Columbia. A federation of 21 municipalities, one Electoral Area, and one Treaty First Nation, it provides utility services on a regional scale, owning and operating drinking water treatment and regional distribution, wastewater treatment, and solid waste management.

Metro Vancouver aims to foster industrial symbiosis at each of its five WWTPs (also called integrated resource recovery and/or residual management facilities). This is a multi-pronged program aimed at utilizing solid and liquid waste from its WWTPs and generating energy. The program is also leveraging WWTP capital upgrades to ensure new plants are designed from the start to facilitate industrial symbiosis (or integrated resource recovery (IRR)). This approach looks at waste as a valuable resource and not simply as something that must be disposed of. When wastewater is treated, organic materials and other products are separated out from the wastewater stream. Instead of being thrown out, these materials can often be recycled to produce heat and electricity, biosolids and other products.

Four of Metro Vancouver's WWTPs use wastewater to generate heat and/or electricity, which is then used to offset the plants' energy requirements, reducing their operating costs and greenhouse gas emissions. Metro Vancouver converts biosolids from its treatment plants to create Nutrifor™, a fertilizer made from biosolids since 1990. They received the 2010 Award of Excellence from the Northwest Biosolids Management Association. Nutrifor™ has been applied at the Vancouver International Airport, the Sea-to-Sky Highway between Vancouver and Whistler, numerous landfills and mine reclamation sites, gravel pits, rangelands, city parks, and silviculture projects. Metro Vancouver continues to explore new opportunities and partnerships to support expanded energy recovery from wastewater to better access and use sewer heat, biogas, and biosolids. In addition, Metro Vancouver is collaborating in international research to develop technologies to create biocrude from wastewater.

Metro Vancouver's current wastewater-related industrial symbiosis research efforts include:

- A pilot project at the Annacis Island wastewater treatment plant is testing how to use energy-rich waste from sources like food processing and restaurant grease to generate heat and electricity. This energy could then be used by the treatment plant to help meet its energy needs.
- The Lulu Island wastewater treatment plant is testing technologies that will create more biomethane from its treatment processes. The biomethane will eventually be sold to Fortis BC, displacing fossil natural gas use in the region.
- Research is being conducted on using wastewater, which is full of nutrients, to grow algae. This algae could then be turned into biofuel via various production pathways.
- Metro Vancouver is working to enable municipalities to use energy from sewers to heat nearby buildings.

Metro Vancouver was also a significant contributor to the NISP® Canada pilot, and has been working with its member municipalities to capture construction and demolition waste for re-use, sponsoring a pilot project in 2010, and developing a template deconstruction bylaw.

Metro Vancouver Summary

Organizational Structure	Program Category
Publicly-owned regional multi-utility	Self-organized (with support for external facilitated industrial symbiosis program)
Funding Source	Budget
Utility fees, e.g., water sales to municipal governments, discharge and permit fees, plus pilot project funding as grants from senior levels of government	n/a (although contributed \$76,000 to NISP® Canada Pilot)

Status	Start Date	End Date
Ongoing	n/a	n/a

Program Outcomes

Solid Waste Diverted	88,000 tons of biosolids in 2016
GHG Emissions Avoided	Generated 522,000 GJ in 2016 (across 5 WWTPs)
Economic Benefits	n/a
# Businesses / Synergies	<10

*NISP® Canada Metro Vancouver Pilot Outcomes documented separately

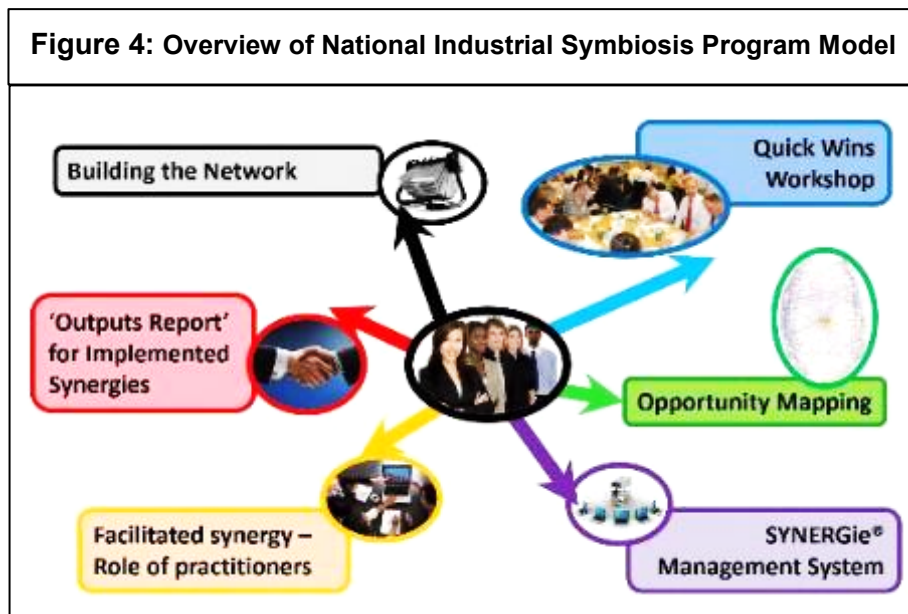
Program Contact

Lead Organization	Contact
Metro Vancouver	Jeff Carmichael Division Manager, Utility Research and Innovation, MSUS, Liquid Waste
www.metrovancouver.org/media-room/video-gallery/mv-video/277699619	jeff.carmichael@metrovancouver.org

National Industrial Symbiosis Programme (NISP®) UK

Conceived, developed and implemented by International Synergies Limited, the National Industrial Symbiosis Programme (NISP) was the world's first national industrial symbiosis program.

The NISP® model overcame the limitations of ICT-driven programs by using facilitators to guide businesses to find potential symbiosis opportunities via quick-wins workshops without requiring quantitative data up-front, and then by deploying facilitators to help time-starved and sometimes capacity-limited businesses actually evaluate and implement their symbiosis opportunities. By taking a regional, inclusive approach to participation, NISP® helped to advance the number of industrial symbiosis participants. More importantly, and unexpectedly, the NISP® model greatly increased the economic and environmental benefits from industrial symbiosis in a given timeframe compared to larger, more traditional industrial symbiosis projects. The NISP® model does incorporate an ICT platform (SYNERGie®), but its focus is on assisting facilitators and in supporting program performance monitoring rather than on collecting data directly from businesses. A detailed description of the NISP® model may be found in the feasibility study for NISP® Canada, available in Appendix A:



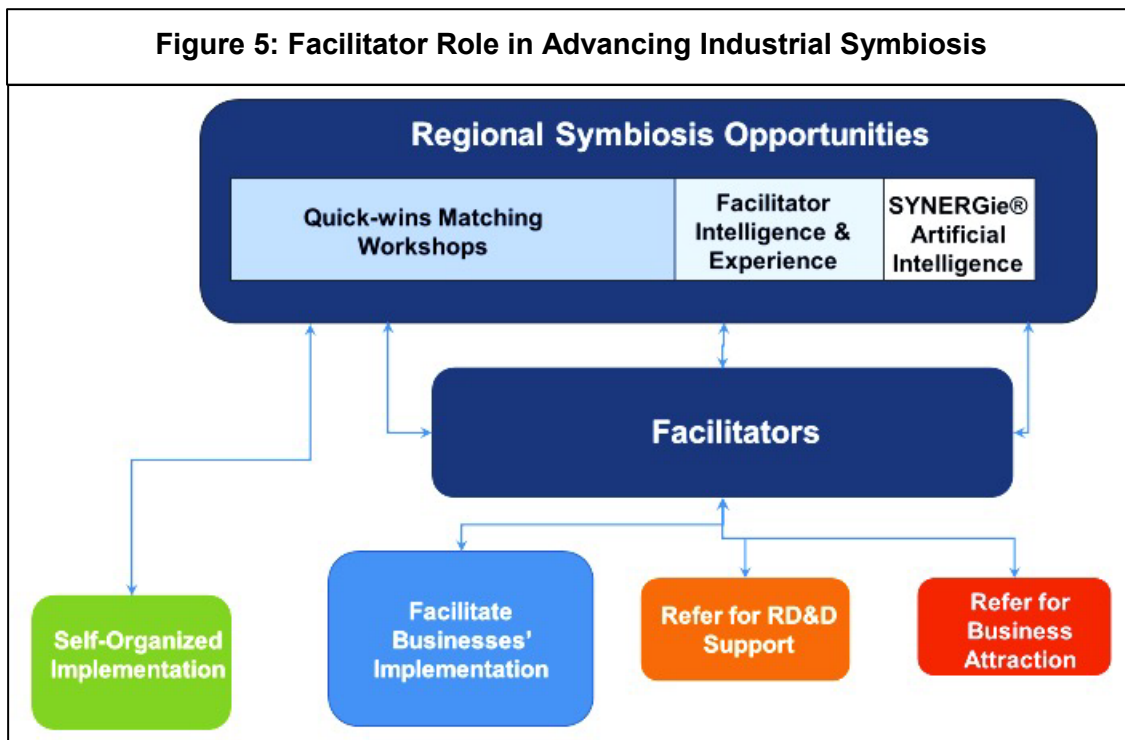
NISP® originated in 2003 as three regional pilot schemes in Scotland, West Midlands, and Yorkshire and Humberside. Based on the regional pilot success, in 2005 the Department for Environment and Rural Affairs (Defra) awarded International Synergies a contract for services worth \$34 million over three years to roll out the program across nine English regions. The following year, funding was secured that enabled the program to expand to Wales, Scotland and Northern Ireland, thereby covering the whole of the UK.

In 2011, the results of the first full five years of NISP® UK (2006 to 2010, inclusive) were third-party audited and verified. The results far exceeded Defra's expectations, and the audit also determined that there were significant, unanticipated carbon savings, as well as

economic benefits that included the creation or avoided loss of 13,000 jobs and a return to Treasury of 7:1 on its investment through Defra. The audit results are documented in a report titled “National Industrial Symbiosis Program: The Pathway to a Low Carbon Sustainable Economy.”²

The contract continued until 2014, when political changes saw support for NISP® cast as a “subsidy to business” despite its demonstrated return on investment to Treasury and its quantitative environmental outcomes. More recently, NISP® UK activities have been partially funded through European Regional Development Fund initiatives. This scenario has not only decreased business participation in industrial symbiosis but also serves as a real-life example of the value of and need for sustained government financing and investment in facilitated industrial symbiosis.

Once the success of the NISP® UK became publicly documented via the Pathway report, interest in the NISP® model increased, and it is now recognized that NISP® is the most successful facilitated industrial symbiosis model globally, with adaptations in 35 countries at local, regional or national levels. The success of the NISP® model actually underpins (by giving a compelling evidence base) EU support for facilitated industrial symbiosis support.



NISP® UK has generated thousands of industrial symbiosis projects. With its drive for RNG and significant biobased industrial activity, the following example is especially relevant to Washington.

² www.wrap.org.uk/sites/files/wrap/Pathway_Report.pdf

Apetito Ltd is a leading supplier of frozen food and catering solutions all over Europe. Apetito contacted the NISP team to help identify an alternative to sending its pastry waste to landfill.

Andigestion Ltd generates electricity by treating a range of organic waste streams through anaerobic digestion. Andigestion was keen to increase electricity production and contacted NISP to source additional streams for input into the plant.

The NISP team's knowledge of regional resource streams and flows led them to foster a link between the two companies.

Subsequent negotiations highlighted that Andigestion could help Apetito with some of its other waste streams such as animal by-products and process effluent in addition to the pastry waste. An agreement was quickly reached between the companies that had clear benefits for both parties, including reduced waste disposal costs, increased sales, and a reliable source of waste for the Andigestion plant. The resulting symbioses reduced greenhouse gas emissions by 7,540 tons, diverted 1,870 tons from landfill, and reduced costs by \$77,000.

Other symbiosis projects resulting from NISP® UK include:

- Heat and CO₂ from a fertilizer manufacturer used by a greenhouse-based fruit grower.
- Waste heat and bone meal from a rendering plant used to offset fossil fuel in the cement industry.
- Various types of alternative raw materials from a variety of sectors now utilized by the construction industry for cement, concrete and roads.

Photo 2: Andigestion Facility



NISP® UK Summary

Organizational Structure	Program Category
Private contracted to NGO (funding recipient)	Facilitated
Funding Source	Budget
National government (Department for Environment and Rural Affairs) for 11 years, then combination of business contributions and European Regional Development Fund grants.	\$1.2 million per region per year (\$34 million for nine regions for three years in 2005)

Status	Start Date	End Date
Ongoing	2003	ongoing

Program Outcomes

Solid Waste Diverted	~5,900,000 tons per year
GHG Emissions Avoided	~5,790,000 tons per year
Economic Benefits	New sales: ~\$160 million per year Reduced costs: ~\$160 million per year Jobs created and safeguarded: ~1,250 jobs per year
Other Benefits	Hazardous waste diverted: ~248,000 tons per year Virgin material saved~ 8,300,000 tons per year Industrial water saved: ~ 1,005,000,000 tons per year
# Businesses / Synergies	Over 15,000 participating industry members in 8 years

Program Contact

Lead Organization	Contact
International Synergies Limited	Peter Laybourn, Chief Executive
www.international-synergies.com/projects/national-industrial-symbiosis-program	Peter.Laybourn@international-synergies.com

NISP® Canada

The following is excerpted from the NISP® Canada pilot performance report, for which the Executive Summary may be found in Appendix B.

Although the NISP® model had been adapted to 35 countries, Canada's unique geography, federal structure resulting in multiple environmental regulatory jurisdictions, and subject matter expert-dominated economy raised questions regarding the applicability and achievable benefits in Canada. So, a pilot was required.

NISP® Canada was piloted in the Metro Vancouver and Greater Edmonton regions for 20 months (October 2017-May 2019), including six facilitated workshops and the retention of two full-time practitioners per region. The pilot was a program of Light House Sustainable Building Centre, a Vancouver-based non-profit.

The pilot engaged more than 350 organizations, drawing out more than 1,900 material, water, or energy-based "waste" resources for a potential 3,500 industrial symbiosis opportunities. The pilot was considered to be a success, and outcomes were in line with other international experience. The pilot also determined that regulations were not a barrier to industrial symbiosis for businesses, except when there was regulatory uncertainty in new industries (algae-based aquaculture and cannabis.). The pilot also helped to define regional delivery size in the Canadian context. Although some businesses drove more than 400 km (250 miles) to participate, generally, most businesses came from within a maximum 100 km (60 mile) radius to participate. Rural regions will be larger and must be resourced for greater practitioner travel, as well as more practitioner site visits.

The NISP® pilot was run on a cost-recovery basis. It is believed that, as with the international experience, grant-funding, especially from government, will be the main short-term funding model. However, it is crucial that government agencies consider that not all low carbon, circular economy solutions involve capital projects; it is difficult for NISP® Canada to fit in such funding programs, despite its ability to deliver on stated policy objectives.

Kruger Products is an example of industrial symbiosis supported by NISP Canada:

Kruger Products produces facial tissue at its New Westminster plant. They achieved FSC® certification in 2011, the first tissue company in Canada to do so. Fabcycle operates firmly in the circular economy, collecting textile waste from apparel production and facilitating its reuse. Fabcycle was seeking heavy-duty tubes to help organize the textiles in the storefront. During a site visit to Kruger, a NISP® practitioner noticed cardboard tubes in the waste bin, resources which weren't originally tabled at a workshop. The practitioner was able to broker the transfer of tubes from Kruger to Fabcycle.

NIPS® Canada Summary

Organizational structure	Program Category
Private not-for-profit	Facilitated (with ICT support)
Funding Source	Budget
Grants from four levels of government: Western Economic Diversification, Metro Vancouver, City of Edmonton, City of Surrey, City of New Westminster, Innovate BC, BC Energy & Mines, BC Ministry of Agriculture, and BC Citizen Services and Community Development (now BC Municipal Affairs).	\$1 million (Canadian)

Status	Start Date	End Date
Ongoing	2009	n/a

Program Outcomes

Solid Waste Diverted	~167,000 tons per year
GHG Emissions Avoided	~15,240 tons per year
Economic Benefits	Cost savings: ~\$680,000 per year Additional sales: ~\$2.2 million per year Return on investment: 7:1 on government investment (including carbon pricing)

Program Contact

Lead Organization	Contact
Light House Sustainable Building Centre Society	Tracy Casavant Managing Director, NISP® Canada & Circular Economy
nispcanada.ca/	tracy@lhsbc.com



The (Invest NI) Industrial Symbiosis Service

The (Invest NI) Industrial Symbiosis Service³ was established in Northern Ireland as part of NISP® UK in 2007 and remains active to this day. It was recently extended to 2024. Facilitation is provided free at the point of delivery for members, who are recruited through workshops and other direct means. Facilitators work with businesses to advance implementation, and also help to identify potential synergies between businesses already in the network but who were not at the same workshop.

The main program website highlights selected business “haves” and “wants,” but this information serves more as an example of the types of resources that could support industrial symbiosis, rather than resulting in much implementation.

Similar to findings for online waste exchanges, a facilitator is required to not only identify potential matches, but to facilitate the evaluation and implementation of such matches. The Industrial Symbiosis Service illustrates two important points. First, that facilitated industrial symbiosis works in a relatively small economy dominated by subject matter experts. Second, that even after 12 years of continuous provision, there is no sign of either diminishing returns or saturating demand.

A sample industrial symbiosis catalyzed by this program is described below:

ThyssenKrupp Aerospace UK Ltd’s Newtownards facility supplies aluminum alloy technology solutions to the local aerospace sector. The company receives raw materials covered in weatherproof PVC tarpaulins to protect the material during transit. The tarpaulins were being sent for disposal to landfill until the NISP® Ireland service identified a more cost-effective and environmentally sustainable solution for the material.

ThyssenKrupp was introduced to Belfast-based Tedfords Ltd which manufactures custom products for the boating, banner and trailer markets. Tedfords has found an additional source of raw material by utilizing the skills of its workforce to reuse and rework the PVC sheets into new products like boat covers and trailer tarpaulins.

This synergy has achieved cost savings and additional sales for both companies. ThyssenKrupp has not only improved its environmental credentials in line with company policy but also found a sustainable solution for a reusable resource.

³ www.investni.com/support-for-business/industrial-symbiosis.html

Invest NI Summary

Organizational structure	Program Category
Regional Economic Development Agency, Contracted Facilitator Firm	Facilitated
Funding Source	Budget
Invest Northern Ireland (regional agency funded by national government)	\$280,000 per year ⁴

Status	Start Date	End Date
Ongoing	2007	Ongoing

Program Outcomes

Solid Waste Diverted	~36,400 tons per year
GHG Emissions Avoided	~34,200 tons per year
Economic Benefits	Costs saved: ~\$2.8 million per year Additional sales: ~\$1.8M million per year Private investment: ~\$217,000 per year Jobs created + safeguarded: ~9 per year Return on investment: 15:1 on government investment
# Businesses / Synergies	Not published

Program Contact

Lead Organization	Contact
International Synergies NI Limited	Elaine Kerr
www.investni.com/support-for-business/industrial-symbiosis.html	Elaine.Kerr@international-synergies.com

⁴ bidstats.uk/tenders/2019/W40/712048802

Southern Waste Information Exchange, Florida

The Southern Waste Information Exchange (SWIX), based in Tallahassee, Florida, has been operating for 38 years under the same CEO. With steady funding from the state since its inception, SWIX almost functions as a quasi-government waste management and recycling organization, hosting not only the waste exchange platform, but conducting events such as electronic waste collection and marine debris clean-ups, providing links to information on recycling, solid and hazardous waste management, and various reports and resources, providing a green products vendor database, and hosting conferences.

The waste exchange service is free to industries. Users can post waste, used or surplus materials and equipment they want or have. The site functions similar to classified ads. There appear to be quite a number of international postings as well. Postings do not indicate when successful connections have been made. Most materials posted are scrap materials (e.g., PET, ABS, HDPE from computer product manufacturing, bottles, various forms of packaging). Chemical wastes are also very prominent (e.g., calcium fluoride, hexane, scrap materials such as wood, copper wire, aluminum). Average quantities are many metric tons (often 100+), and some are continuously produced.

As of October 15, 2019, the site indicated it had 932 listings. The first 71 appear to be entries from 2019, but include some international products, e.g., Himalayan pink salt from the United Arab Emirates. Filtering for “copper” produced 25 listings, only one of which was from 2019 and 12 of which were as far back as 2011. Filtering for “plastic” returned 100 results, two of which were from 2019: one in Florida, and one in California.

SWIX Summary

Organizational Structure	Program Category
Non-profit partnership of Florida State University, Florida Chamber of Commerce, and the Florida Department of Environmental Protection	Passive / Database
Funding Source	Budget
State grants	Estimated to be \$300,000 per year

Status	Start Date	End Date
Ongoing	1981	n/a

Program Outcomes

Solid Waste Diverted	69,133 tons
GHG Emissions Avoided	n/a
Economic Benefits	Cost savings: ~\$92,000 per year Return on investment: \$12.86 economic value per dollar invested
# Businesses / Synergies	~1,000 engagements per year

Program Contact

Lead Organization	Contact
Southern Waste Information Exchange	Gene Jones, CEO and President
www.swixusa.org southernwasteinformationexchange.com/	gene@swixusa.org

Circulate Industrial Ecology Program, NSW, Australia

Circulate is a six-year, \$3.74 million program designed to support the recovery of commercial and industrial (C&I) and construction and demolition (C&D) waste from organizations across the state of New South Wales (NSW) in Australia. Recipients develop synergies with other industries to identify industrial ecology opportunities, increase efficiency, and save money by reducing waste sent to landfill. Circulate supports projects that recover materials otherwise sent to landfill for use as feedstock for other commercial, industrial or construction processes.

Circulate seeks to engage 1,000 medium-to-large enterprises to establish approximately 100 industrial ecology projects. During this period the program is targeting 176,000 tons of landfill diversion and \$14 million in additional income and/or savings for participating businesses. The program will focus on the recovery of wastes currently being sent to landfills.

To date, there have been three funding rounds disbursing \$2.98 million to 27 symbiosis projects. One example of a successful symbiosis project is presented below:

Approximately 1.25 million mattresses are sent to landfill each year in Australia. Each mattress contains 12.5 kilograms of steel, 2 kilograms of wood, and 1.5 kilograms of foam. Only a small portion of mattresses disposed of each year are recycled. The rest end up in landfill, taking up a massive 0.75 cubic meters of landfill space per mattress. The mattress recycling project aimed to achieve higher recycling rates by: 1) developing and implementing a voluntary stewardship program with mattress manufacturers and retailers, and 2) increasing mattress recycling tonnage through a point-of-sale take-back program. The mattress recycling project targeted industry wholesalers and retailers Harvey Norman, IKEA, AH Beard, Sealy, Fantastic Furniture, DeRucci, and Comfort Group.

The mattress recycling project has resulted in the development of a voluntary stewardship program with manufacturers and retailers, which is currently achieving diversion of 120,000 mattresses per annum. Retailers IKEA and De Rucci committed to point-of-sale recycling resulting in a 12-month forecast in the first year of 1,315 tons including an additional 934 tons of steel, 160 tons of foam, 33 tons of textiles, 87 tons of timber, and other materials. This additional recycling in the first year is estimated to save 40,049 cubic meters of landfill space.

Examples of Round 3 funded projects are presented below:⁵

- Cross Connections Consulting Pty Ltd. is conducting a pilot to collect soft plastics from businesses every two weeks and then reprocess the plastics to make benches, garden beds and fencing.
- Stephen Consulting Group Pty Ltd. will commission a customized mobile baler to bale soft plastics, which will be dry cleaned and reprocessed into cable covers, garden edging and root guard.
- Bottlecycler Sydney North t/a European Baler Rentals (EBR) will establish a network of commercial and industrial sources of plastic milk bottles and develop a logistics network to facilitate recycling the bottles into virgin-replacement resin.
- Closed Loop Environmental Solutions Pty Ltd. will work with Simply Cups, an existing coffee cup recycling program, to increase the quantity of coffee cups collected for reprocessing from office buildings, as well as collection places in public spaces such as shopping centres, entertainment precincts, airports, hospitals, and other businesses.
- Good360 Australia Pty Ltd. aims to identify and recover unsold non-perishable personal care items, currently stored in warehouses, back into the productive economy. Materials will be redirected for social benefit through refuges and shelters.
- Vinindex Pty Ltd. will collect residual polyvinyl chloride (PVC) from construction and demolition and commercial and industrial waste streams to process for use in the production of plastic pipes and fittings.
- WastePro 3BL Pty Ltd. will establish a model and technology platform to enable the regional collection and processing of expanded polystyrene on the Central Coast. It will engage social and disability enterprises to enable meaningful work and revenue streams. It aims to demonstrate a successful platform and business model for state-wide rollout.
- Winya Indigenous Furniture Pty Ltd. reports that up to 99 percent of used office furniture is currently sent to landfill. Used office furniture will be collected and disassembled, the metal recycled, and the melamine removed. Medium-density fibreboard and particleboard will be recycled into e-board for use in new office furniture by indigenous staff.

Based on the types of projects funded, Circulate seems to be particularly effective at catalyzing solutions for municipal solid waste and post-consumer waste streams, such as plastic bottles and film, mattresses, and polystyrene, that is, solutions for materials collected via residential and commercial recycling schemes.

⁵ Excerpted from www.epa.nsw.gov.au/working-together/grants/business-recycling/circulate-grant

Circulate Summary

Organizational structure	Program Category
State government	Self-organized (Technical, RD&D)
Funding Source	Budget
State government	~\$624,000 per year


Status	Start Date	End Date
Ongoing	2017	2022

Program Outcomes

Solid Waste Diverted	~28,000 tons per year
Economic Benefits	Actual: not reported Target: \$21 million AUS in new revenues plus savings for businesses
# Businesses / Synergies	28 projects (grants) so far, some projects involve multiple businesses

Program Contact

Lead Organization	Contact
New South Wales Environment Protection Authority	Waste and Resource Recovery Branch, Business Recycling Unit, NSW EPA
www.epa.nsw.gov.au/working-together/grants/business-recycling/circulate-grant	industrial.ecology@epa.nsw.gov.au



Washington Industrial Waste Coordination (Industrial Symbiosis)

Program Recommendations

Appendix B:

Canadian Industrial Symbiosis Program Feasibility Study

NOVEMBER 2019

LIGHT HOUSE SOCIETY

**with International Synergies Ltd.
and Center for Sustainable
Infrastructure**

PREPARED FOR

**Washington State
Department of Commerce**





NATIONAL INDUSTRIAL SYMBIOSIS PROGRAM

MODEL FEASIBILITY STUDY FOR CANADIAN ADAPTATION

**Prepared by Light House Sustainable Building Centre
June, 2016**

AUTHORSHIP

Light House Team

Tracy Casavant, Director, Resource Innovation
Katherine Bergeron, Social Impact Coordinator
Krista Funes, Industrial Symbiosis Research Volunteer
Sarah Goble, Industrial Symbiosis Research Volunteer

ACKNOWLEDGEMENTS

We would like to thank the following people for their technical review of this study:

Luke Smeaton, Executive Director, Light House
Ted Sheldon, Clean Energy Advisory, BC Ministry of Energy & Mines
Nadine Diner, Director of Industry Initiatives, Industry and Innovation Group, BC Innovation Council



© 2016 Light House Sustainable Building Centre Society. All rights reserved

EXECUTIVE SUMMARY

Symbiosis in Action

Guinness Power

Quality control batches of Guinness Beer (which become unsaleable) used to be discharged to sewer. Now, they are sent to Diageo's power producing anaerobic digester.

A Fruitful Collaboration

Terra Nitrogen Ltd by-products of CO₂, and steam are now with a 38 acre greenhouse owned by John Baarda Ltd. Now, British greenhouse tomatoes compete Spanish ones in the winter!

Unlikely Playdate

Clean offcuts of light insulation foam used by Dunlop Marine to make hoses for offshore oil & gas industry are diverted by landfill and now used by North Lincs in the manufacture of children's teddy bears.

The Other 'Green' Roof

Used plastic milk jugs and plastic bags are now being reprocessed and manufactured into GR Green's roofing tiles.

The National Industrial Symbiosis Program (NISP) model was developed and first delivered in the UK, starting in 2005. Having completed their own due diligence, more than 20 countries have now implemented the model. **The objectives of this feasibility study are to evaluate the NISP model and to determine the viability of applying the NISP model in Canada.**

What is Industrial Symbiosis?

Industrial symbiosis refers to business-to-business relationships that mimic symbiotic relationships between organisms in nature, where 'waste equals food'. In practice, industrial symbiosis involves the waste of one or more businesses (or similar operations, such as a municipal wastewater treatment plant) being diverted to become an input to one or more other businesses. Symbiosis can occur between businesses in the same sector or businesses from different sectors.

What is the 'NISP' Model?

The National Industrial Symbiosis Program (NISP) model was developed in the UK in 2005. The NISP model has delivered documented, significant environmental, social and economic benefits. There are now programs based on the NISP model running more than 20 countries. The NISP model relies on **facilitated** industrial symbiosis. The model has four distinct components:

- Facilitated workshops, rather than technical studies, are used to identify industrial symbiosis opportunities;
- Synergie™, an information technology (IT) platform, supports practitioners and ensures that all benefits are accurately quantified.
- Locally-based practitioners, trained to international NISP protocol are **dedicated** to nurturing industrial symbiosis opportunities from idea to implementation.
- No cost to businesses' participation – businesses can participate in workshops and utilise the services of the NISP practitioners free of charge.



Figure ES1: NISP model workshops (Egypt – right, France – left)

NISP-CANADA: FEASIBILITY CONCLUSION

The NISP Model is Feasible

The NISP model has been independently evaluated; independently audited; and proven to be adaptable, as it is now operating in more than 20 countries. The feasibility of the NISP model has been well-demonstrated internationally.

The NISP model supports Canada’s national and international policy goals.

The verified success, and proven flexibility and adaptability indicates that NISP should be as feasible in the Canadian context as it has proven successful in the 20 other jurisdictions to-date.

The NISP model has been **independently evaluated**. It has been identified by several organizations, including the Global Green Growth Forum, EC Directorate General for the Environment, and World Wildlife Fund, as being one of the top international best practices for achieving resource efficiency and fostering sustainable business activity.

The NISP model has been **independently audited**. The NISP model has proven, measurable benefits such as reducing greenhouse gases, reducing waste materials to landfill, strengthening businesses competitiveness, creating jobs, and building skills and capacity to support a circular, low carbon economy. Its methodologies for calculating the benefits from implemented symbiosis opportunities has been verified, and the scale of benefits achieved in the UK has been confirmed. The auditors verified the NISP-UK reported benefits from 2005-2010, and also modeled the long-term impact from the symbiosis opportunities implemented during that time i.e., a savings of 100 tonnes per year achieved in year 4 would continue to provide benefits in subsequent years. Two separate long-term models were created: Scenario 1 assumed persistence with 20% decay (diminishing benefits) per year, while Scenario 2 assumed persistence with 0% decay per year. Neither scenario considered the additional implementation of new symbiosis opportunities still ‘in the pipeline’ as of 2010. Selected audit results are shown in Table ES1, below:

Table ES1: NISP-UK 2005-2010 Audited Results

NISP-UK Delivered Outcomes 2005-2010			
Metrics	Actual Benefits 2005-2010	Lifetime Benefits Scenario 1	Lifetime Benefits Scenario 2
Landfill diversion	7.0 million tonnes	21 million tonnes	35 million tonnes
CO2 reduction	6.0 million tonnes	18 million tonnes	30 million tonnes
Virgin Materials savings	9.7 million tonnes	29 million tonnes	48 million tonnes
Hazardous waste eliminated	0.4 million tonnes	1.0 million tonnes	1.8 million tonnes
Water reduction	9.6 million tonnes	29 million tonnes	48 million tonnes
Cost savings	156 million £	468 million £	780 million £
Additional sales	178 million £	528 million £	880 million £
Jobs created	3.6 thousand	13 thousand	22 thousand
Jobs saved	5.0 thousand	18 thousand	31 thousand

The NISP model has **proven to be adaptable**, with initiatives based on the model now running in 21 countries. As the NISP network has grown, the framework has proven itself adaptable to different geographies and financial models. NISP has proved its flexibility to being adapted to many contexts, with varying geographical or financial conditions. For example, in Holland where there is only one central industrial region, NISP becomes a singular regional program, whereas in Turkey, with multiple industrial regions under largely national control, an expansive program was rolled-out in a short-period of time, regionally delivered and nationally funded and orchestrated. Holland funds the program solely on government funds, whereas Belgium is half funded by government and the chemical industry.

The NISP model **supports Canada's national and international policy commitments**. Therefore, the Canadian government, and, provincial and municipal governments, should support the establishment of a NISP in Canada. The NISP model supports several of the federal governments targets related to goals for tackling climate change and advancing clean technology outlined in the Draft Federal Sustainable Development Strategy. The NISP model also supports Canada's international commitments made under COP21, the G7 (via its Alliance for Resource Efficiency) and the United Nations Sustainable Development Goals.

NISP Model: Considerations for Canadian Adaptation

The Canadian context does raise some unique organizational questions that must be answered before the model can be readily replicated in regions across Canada. These questions, and a possible plan for addressing them, are presented below. Given the nature of the questions, and the challenges in general with respect to national co-ordination across a federation structure, we recommend that NISP be adapted to Canada in two or more regional pilots first. Such pilots would help to answer these questions, and would shape a 'Made in Canada' NISP initiative.

HOW BIG IS A 'REGION'?

A metropolitan area? A province? It is not clear how far and wide the generally minimum two regional practitioners could reach. It is also not clear how far businesses would travel to attend a workshop, or at what scale geography begins to present a common barrier to an otherwise viable symbiosis business case. Any pilots will seek to provide a better understanding of business participation rates and businesses' need for practitioner assistance in advancing the symbiosis opportunities identified at the workshop.

HOW MANY AND WHAT REGIONS ARE DESIRABLE FOR A NATIONAL PROGRAM?

The UK program was ultimately delivered across the whole of England in 13 regions, following the boundaries of its regional economic development authorities. Falling out of the unknowns related to the required size of a Canadian region, it's not known how many regions should be included in a Canadian national program. For example, should a 'national' program in Canada focus on the metropolitan areas around cities represented by the Big City Mayors' Caucus, or include other regions as well?

WHAT ARE THE OPTIONS FOR FINANCING THE PROGRAM?

The international precedent is generally for the majority of funding/investment to come from national (or EU) government sources. In the short to medium term, investing in a 'NISIP-Canada' is an attractive value proposition for policy makers /governments who are already investing significant amounts to achieve the combined aims of job creation, growth, innovation, competitiveness, and greenhouse gas emission reduction.

Long-term, it is not likely politically palatable for a NISIP-Canada to be primarily funded by the federal government. Long term funding will be greatly influenced by the results of any pilot. For example, it's possible that, like Belgium, certain sectors see great success and those associations are therefore incentivized to fund the program long term. Alternative finance mechanisms should also be explored, such as green bonds, social impact bonds, and the establishment of a trust into which a portion of companies' savings from implementing symbiosis could be deposited and used to sustain the program. The European Commission's Directorate General for the Environment commissioned a report in 2011 that, while endorsing the NISIP model, did note that scaling could be affected by limited funds (Economic Analysis of Resource Efficiency Policies, 2011, see also Appendix G). Should Canada be able to develop some alternative funding models, there would likely be significant international interest in learning from and adapting these models to other NISIP initiatives.

It should also be noted that, to secure government funding, both the Canadian and provincial contexts would likely require NISIP to be housed within a not-for-profit entity. However, this should also be confirmed during any pilot.

HOW DO THE BENEFITS SEEN IN THE UK SCALE TO A CANADIAN REGION?

And what might that mean for benefits in other regions in Canada? The geographic, regulatory, and economic landscape is not only unique at the national scale, but also varies regionally as well. It's not known how the benefits scale to regions with less heavy industry, or what the influence is, if any, of policies such as a carbon tax or strong extended producer responsibility legislation.

In conclusion, while it is most certainly feasible to apply the NISIP model in the Canadian context, there are some considerations that may shape the final form of any NISIP-Canada. Regional pilots would help to answer outstanding questions. The answers to these questions will: maximize the success of a regional model; shape a sustainable, multi-region "Made-in-Canada" program; and provide yet another valuable case study to the growing number of countries exploring how best to adopt NISIP to meet their national and local sustainable business objectives.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	ii
INTRODUCTION	1
INDUSTRIAL SYMBIOSIS MODELS	2
SUMMARY OF MODEL TYPES	2
NISP MODEL	4
OVERVIEW	4
FACILITATED WORKSHOPS.....	4
SYNERGIE™ PLATFORM	5
DEDICATED PRACTITIONERS & REGIONAL ADVISORS.....	7
NO COST PARTICIPATION	7
SUMMARY OF EXISTING EVALUATIONS & POLICY	8
INTRODUCTION	8
THE PATHWAY TO A LOW CARBON SUSTAINABLE ECONOMY, 2010	8
GREEN GAME-CHANGING INNOVATION: NEW BUSINESS THINKING FROM AROUND THE WORLD, 2010	10
GLOBAL GREEN GROWTH FORUM (3GF) INDUSTRIAL SYMBIOSIS PARTNERSHIP	10
ECONOMIC ANALYSIS OF RESOURCE EFFICIENCY POLICIES, 2011	12
CIRCULAR ECONOMY IN EUROPE: DEVELOPING THE KNOWLEDGE BASE, 2016.....	12
CANADIAN NATIONAL & INTERNATIONAL POLICY ALIGNMENT	13
DRAFT FEDERAL SUSTAINABLE DEVELOPMENT STRATEGY, 2016.....	13
COP21, 2015.....	13
G7 ALLIANCE FOR RESOURCE EFFICIENCY (G7-ARE), 2015	14
UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS	14
NISP-CANADA: FEASIBILITY CONCLUSION	16
THE NISP MODEL IS FEASIBLE.....	16
NISP MODEL: CONSIDERATIONS FOR CANADIAN ADAPTATION	17

LIST OF APPENDICES

- A. Sample NISP Workshop Summary Report (Gauteng, South Africa)
- B. Sample NISP Regional Results Report Presentation
- C. Selected NISP Case Studies for Completed Symbiosis Opportunities
- D. The Pathway To A Low Carbon Sustainable Economy
- E. Green Game-Changing Innovation: New Business Thinking From Around The World, 2010
- F. Global Green Growth Forum (3GF) Industrial Symbiosis Partnership Documents
- G. Economic Analysis Of Resource Efficiency Policies, 2011
- H. Circular Economy in Europe: Developing The Knowledge Base
- I. Overview of NISP Alignment with Canada's Draft Federal Sustainable Development Strategy
- J. G7 Annex to the Leaders' Declaration, 2015, and G7-Alliance For Resource Efficiency Industrial Symbiosis Workshop Proceedings, 2015

INTRODUCTION

Symbiosis in Action

Guinness Power

Quality control batches of Guinness Beer (which become unsaleable) used to be discharged to sewer. Now, they are sent to Diageo's power producing anaerobic digester.

A Fruitful Collaboration

Terra Nitrogen Ltd by-products of CO₂, and steam are now with a 38 acre greenhouse owned by John Baarda Ltd. Now, British greenhouse tomatoes compete Spanish ones in the winter!

Unlikely Playdate

Clean offcuts of light insulation foam used by Dunlop Marine to make hoses for offshore oil & gas industry are diverted by landfill and now used by North Lincs in the manufacture of children's teddy bears.

The Other 'Green' Roof

Used plastic milk jugs and plastic bags are now being reprocessed and manufactured into GR Green's roofing tiles.

Industrial symbiosis refers to business-to-business relationships that mimic symbiotic relationships between organisms in nature, where 'waste equals food'. In practice, industrial symbiosis involves the waste of one or more businesses (or similar operations, such as a municipal wastewater treatment plant) being diverted to become an input to one or more other businesses. Over time, industrial symbiosis has evolved to include the diversion of waste liquids (including water) and waste energy flows, and has also supported business-to-business collaborations around more intangible resources such as transportation or human resource needs. Symbiosis can occur between businesses in the same sector or businesses from different sectors.

"Industrial symbiosis is a solution ready to be scaled. It has been estimated by International Synergies Limited, the partnership hosts, that the potential global impact of large scale industrial symbiosis could be around US\$7.7 billion per annum from an annual investment of only US\$213 million."

Global Green Growth Forum

The National Industrial Symbiosis Program (NISP) model was developed and first delivered in the UK, starting in 2005. Having completed their own due diligence, more than 20 countries have now implemented the model.

The objectives of this feasibility study are to evaluate the NISP model and to determine the viability of applying the NISP model in Canada.

The feasibility study comprises three parts:

- I. Industrial Symbiosis Models
- II. Summary of Existing NISP Evaluations & Policy: Review of existing international evaluations and policies advancing industrial symbiosis and related to the NISP model; and
- III. NISP-Canada Feasibility Considerations: Implications of international best practice on adapting the NISP model to Canada.

INDUSTRIAL SYMBIOSIS MODELS

Summary of Model Types

Industrial symbiosis (IS) can be catalysed in four key ways: serendipity; passive engagement; data-driven; and facilitated. Table 1 explains each model.

Table 1: Industrial Symbiosis Model Types

	Model Type			
	Serendipity	Passive Engagement	Data-Driven	Facilitated
Description	Isolated examples of industrial symbiosis that was implemented by two businesses with no external help e.g., the businesses met by chance and recognized a specific opportunity.	Waste exchange databases that allow businesses to enter their waste materials and / or search for input replacements. Sometimes supported by a co-ordinator who keeps an eye open for opportunities, or who might connect businesses to resources needed to implement the transaction e.g., a transportation company.	Third-parties visit companies and collect data via surveys, interviews, and waste audits. The third-parties then review the data to look for opportunities. Businesses are provided with just the recommendations, or the third-party is resourced enough to spend time trying to convince the businesses to implement them.	Businesses are engaged as a group, such as in a workshop, where a facilitator helps to identify potential symbiosis opportunities by drawing out businesses' resource stream haves and wants. Facilitators then follow-up with businesses to help them implement the opportunities.
Example	Vancouver Landfill and CanAgro Greenhouses Agricultural Waste to FortisBC Renewable Natural Gas	BC IMEX (Industrial Materials Exchange)	Partners in Project Green Alberta Industrial Heartland Waste Heat Mapping	Kwinana Industries Council (Australia) Western Cape Industrial Symbiosis Program, S Africa (NISP model)

					Model Type					
					Serendipity	Passive Engagement	Data-Driven	Facilitated		
Advantages	No external costs are incurred.				Low operational costs, once database is developed.		Detailed business cases can be developed relatively early in the process. An objective third-party visiting businesses can help to build capacity and support around symbiosis and related sustainability goals.		Results in the highest number of symbiosis opportunities identified and implemented. An objective third-party visiting businesses can help to build capacity and support around symbiosis and related sustainability goals.	
Disadvantages	While such examples are inspirational and may lead to symbiosis opportunities, they do not lead to the systematic embedding of industrial symbiosis in a region.				Most businesses do not have the time or inclination to search the database and then follow-up with the respective company. The information in the database is often technically incomplete and out of date. There are also problems with classifications of materials.		Relatively costly and time-consuming related to the amount of symbiosis implemented. The studies often 'sit on shelves' because the process did not build a relationship between the businesses or the opportunity did not solve a top operational challenge for them.		Highest absolute costs, although most-cost-effective in terms of the number of symbiosis opportunities identified and implemented, and the mass of resources diverted.	

NISP Model

Overview

As this feasibility study was designed to explore the feasibility of adapting to Canada facilitated symbiosis as represented in the NISP model, a more detailed description of the NISP model is presented here. Developed in the UK in 2005 the NISP model has delivered tremendous environmental, social and economic benefits. It is now established and adapted to regions in over 20 countries and counting. The model is built around the principle of engaging people (representing businesses) first, and then providing personal support to advance their symbiosis opportunities. The model has four distinct components:

- Facilitated workshops, rather than technical studies, are used to identify industrial symbiosis opportunities;
- Synergie™, an information technology (IT) platform developed just for the NISP model, supports practitioners and ensures that all benefits are accurately quantified.
- Locally-based practitioners, trained to international NISP protocol and guided by a business-focused Regional Advisory Committee, are **dedicated** to nurturing industrial symbiosis opportunities from idea to implementation.
- No cost to businesses’ participation – businesses can participate in workshops and utilise the services of the NISP practitioners free of charge.

Facilitated Workshops

NISP uses a facilitated process to bring about industrial symbiosis, engaging businesses from the outset via workshops that are facilitated by locally-based practitioners trained according to international NISP protocol. Based on the NISP model, the workshop agenda would generally be as follows, using a start time of 8:00 AM:

8:00	Networking, Registration, Coffee
8:30	Opening address (standard overview presentation tailored to local context)
9:00	Guest speaker(s) (usually local business champions already practising industrial symbiosis; government supporters, etc.)
9:20	Detailed workshop instructions
9:30	Coffee break
9:50	Haves, Wants & Synergies Working session facilitated according to international protocol License includes all training materials, handouts, etc. Frequently, local business champions also receive training ahead of the workshop to provide facilitation support at the working tables.
11:30	Networking, lunch During this time, workshop facilitators (i.e., the local practitioners) review working session outcomes.
12:30	Closing Message

	Reinforce key messages and collective value; remind businesses they can opt-out of sharing data in the workshop outcome mini-report; close with key highlights from the working session
--	---

Ahead of the workshop, businesses are provided with a Workshop Preparation handout to prompt them to begin thinking about resources they have and resources they want. “In the context of Industrial Symbiosis, it is important that ‘resources’ are recognised in their broadest context. There is a natural tendency to think about waste....Your outputs may not be waste-related, but could easily be available resources that you can supply to another company as part of an ongoing agreement.” Businesses are also provided with a worksheet so that they can brainstorm ahead of time what resources they have/need. The worksheet breaks resources down into the following categories: Materials, Capacity, Energy, Land, Logistics, Water, Expertise.

Based on existing NISP programs, an average workshop with 40 attendees results in 400 opportunities, about 40 of which are implemented with the support of a practitioner, and others implemented by businesses without any assistance. At an average of 4 workshops per year per region, the model embeds industrial symbiosis far deeper and more quickly than other approaches such as waste exchange databases or audit-driven programs. Photos showing 2016 workshops in France (left) and Egypt (right) are presented in Figure 1, below.



Figure 1: NISP Workshop Photos (Source: International Synergies Ltd.)

Synergie™ Platform

Immediately following the workshop, the practitioners enter the workshop outcomes into Synergie™. This data includes information about the businesses as well as their haves, wants, and synergy matches made during the workshop. The practitioners then produce a Workshop Outcome Report and circulate it to participants and supporters. Synergie™ also ensures that the performance of every symbiosis opportunity is quantified, with an ability to calculate indicators such as jobs created, greenhouse gas emissions reduced, or solid waste diverted. These calculations support the development of case studies. Furthermore, Synergie™ serves as a growing database of available resources for practitioner to

reference throughout the life of the pilot and program. Selected screenshots of the Synergie® software are shown in Figure 2.

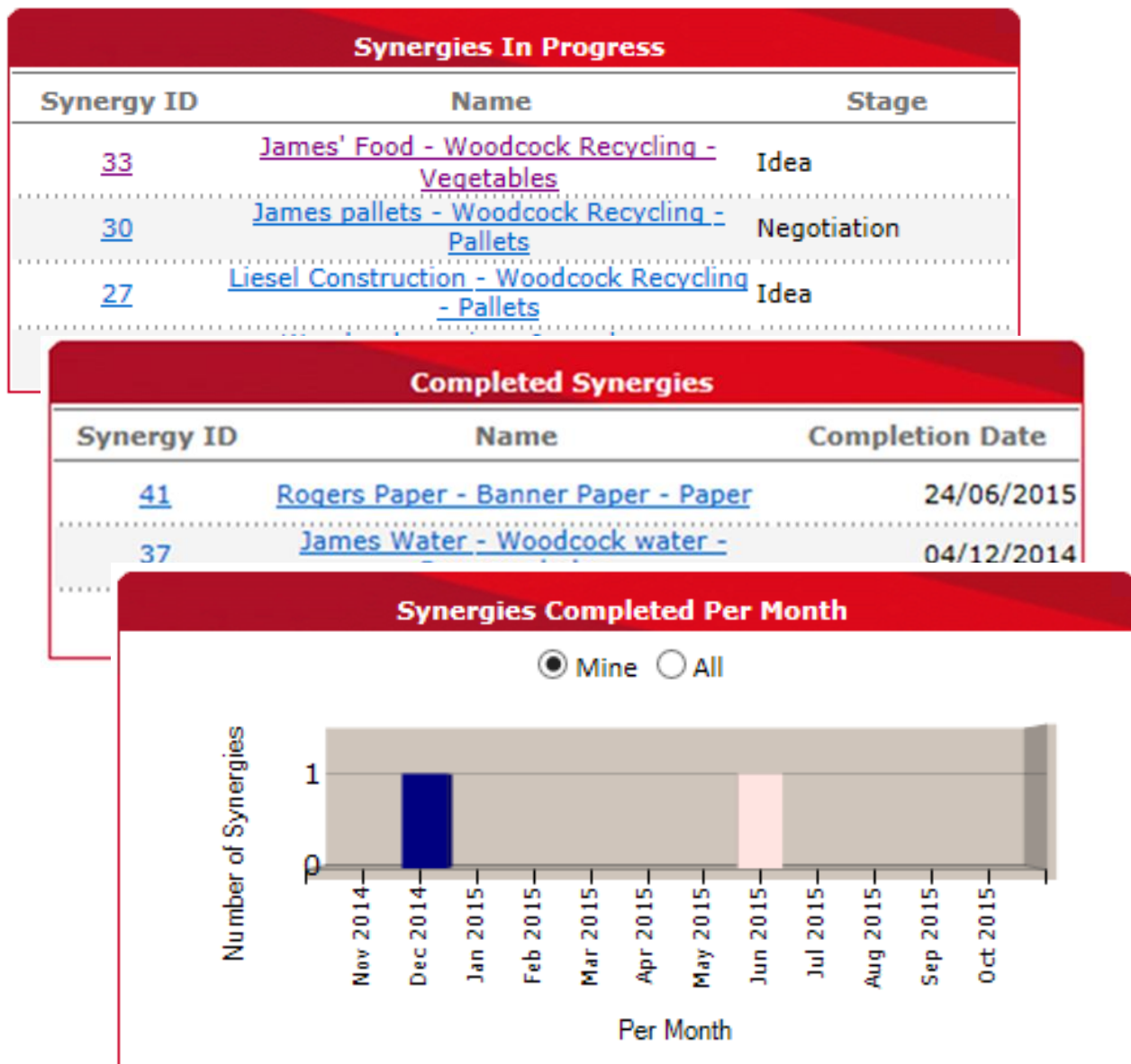


Figure 2: Selected Synergie™ Screenshots

A sample Workshop Outcome Report is attached in Appendix A. A sample Program Outcome Report is attached in Appendix B. Selected Case Studies may be found in Appendix C.

Dedicated Practitioners & Regional Advisors

Then, the dedicated practitioners begin following up on the potential synergies, tracking them in Synergie™ from Idea, to Discussion, to Feasibility, to Negotiation, to Implementation. The dedicated practitioners are critical to the NISP model, and are responsible both for the high idea generation through their facilitation of NISP workshops, as well as for the conversion of ideas into implemented projects. The presence of dedicated practitioners helps to overcome a common barrier, especially within SMEs, related to the availability of time or technical capacity needed to implement a multi-business symbiosis project.

The efforts of the dedicated practitioners are usually supported a Regional Advisory Committee (RAC), comprising primarily regional business sector representatives, plus other government and academic representatives depending on the country's political structure, program funding model, and regional priorities. As one workshop generally produces 10x the opportunities as the number of participants, the RAC can support the practitioner in determining how to prioritise follow-up. For example, based on its knowledge of the regional economy and priorities, a RAC might determine that the dedicated NISP practitioners focus on symbiosis opportunities that involve clean tech innovation, create the most jobs, or reduce carbon footprint. This structure was established to ensure that NISP delivery maximizes value to regional businesses.

The dedicated practitioners themselves are part of an international collaborative network of NISP practitioners that can share knowledge regarding symbiosis successes related to particular materials or business-types. For example, in a country with many regional programs, one region might have a practitioner with extra experience or expertise in a particular industry. That practitioner could provide support to other regional practitioner colleagues working to implement a symbiosis opportunity involving that industry.

No Cost Participation

This model delivers results due to the cost effective approach to businesses and the persistence of trained practitioners. Contrary to other industrial symbiosis models there are no initial auditing costs, the workshops are free to encourage participation particularly from SMEs (where charges are a barrier to entry) and practitioners achieve greater follow through than happenstance waste exchanges. In other countries, program delivery costs (practitioner salaries, training, software licenses, and general management and administration) are generally funded entirely from government sources. The program with the least amount of government funding is the program in Belgium, which is funded 50% by the national government, and 50% by the national chemical producers association. A discussion of the verified cost-benefit ratio for government investment in NISP is discussed as part of the review of the Pathway to a Low Carbon Economy audit report presented in the following section.

SUMMARY OF EXISTING EVALUATIONS & POLICY

Introduction

One of the most comprehensive evaluations of the NISP model was completed in 2010 by Scott Wilson Consultancy ('Wilson') and Manchester Economics ('Manchester'). Wilson and Manchester completed a rigorous verification of the results claimed by the NISP-UK during its first five years of operation, and also evaluated the economic benefits to the UK Treasury, as the UK national government wholly invested in NISP-UK. The Wilson and Manchester findings are presented in the Pathway to a Low Carbon Economy Report, which is summarized in this section of the feasibility study.

In addition to the Pathway to a Low Carbon Economy, there have been additional evaluations of the NISP model that have influenced policy development, particularly within the EU, and have also led to other third-party endorsements of industrial symbiosis, especially as achieved via the NISP model.

This section provides an overview of the seminal Pathway to a Low Carbon Economy Report, as well as relevant policies and endorsements. Where possible, the original source materials have been appended to this feasibility study, as referenced at the start of each sub-section.

The Pathway to a Low Carbon Sustainable Economy, 2010

See Appendix D for the above report, including the Wilson and Manchester reports.

The first five years of the NISP-UK (2005-2010) were third-party audited, verifying impact on: greenhouse gas (GHG) reduction, waste diversion, fiscal performance, and job creation. The auditors verified the NISP-UK reported benefits from 2005-2010, and also modeled the long-term impact from the symbiosis opportunities implemented during that time i.e., a savings of 100 tonnes per year achieved in year 4 would continue to provide benefits in subsequent years. Two separate long-term models were created: Scenario 1 assumed persistence with 20% decay (diminishing benefits) per year, while Scenario 2 assumed persistence with 0% decay per year. Neither scenario considered the additional implementation of new symbiosis opportunities still 'in the pipeline' as of 2010.

Table 2: NISP-UK 2005-2010 Audited Results

NISP-UK Delivered Outcomes 2005-2010			
Metrics	Actual Benefits 2005-2010	Lifetime Benefits Scenario 1	Lifetime Benefits Scenario 2
Landfill diversion	7.0 million tonnes	21 million tonnes	35 million tonnes
CO2 reduction	6.0 million tonnes	18 million tonnes	30 million tonnes
Virgin Materials savings	9.7 million tonnes	29 million tonnes	48 million tonnes
Hazardous waste eliminated	0.4 million tonnes	1.0 million tonnes	1.8 million tonnes
Water reduction	9.6 million tonnes	29 million tonnes	48 million tonnes
Cost savings	156 million £	468 million £	780 million £
Additional sales	178 million £	528 million £	880 million £
Jobs created	3.6 thousand	13 thousand	22 thousand
Jobs saved	5.0 thousand	18 thousand	31 thousand

Government Return on Program Investment

The third-party audit of the NISP-UK program also calculated the cost-benefit ratio for the UK government’s investment of considered the following factors when determining the cost-benefit ratio to the UK Treasury:

- New corporate income tax revenues;
- New personal income tax revenues; and
- New value-added tax (VAT) revenues (Canada’s Goods & Services Tax is a VAT).

The cost: benefit ratio was calculated to be 32:1 to 53:1 depending on the decay assumptions used.

The net Total Economic Value Added (TEVA) also included benefits from indirect jobs and environmental TEVA, using methodology from Her Majesty’s Treasury Green Book, which provides “...guidance for public sector bodies on how to appraise proposals before committing funds to a policy, programme or project” (<https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government>). The net TEVA multiplier ranged from 53.2 to 88.6, depending on the decay assumptions used.

Program Cost Effectiveness

The audit also found that the program became more cost-effective with time. For example, the cost (with respect to government investment) to divert one tonne of material from landfill was £0.58 in year one, but down to £0.15 in year five. The overall cost-effectiveness per metric is summarized in the table below. While the NISP was initiated primarily as a solid waste management initiative, the carbon reductions achieved, as well as the cost to the government for those reductions, were unexpected and significant outcomes.

Table 3: NISP-UK Cost-Effectiveness 2005-2010

NISP-UK Cost-Effectiveness 2005-2010			
Metrics	Proportional Cost to the Government 2005-2010	Proportional Lifetime Cost Scenario 1	Proportional Lifetime Cost Scenario 2
One tonne of waste diversion	56 pence	19 pence	11 pence
One tonne of CO2 reduced	65 pence	22 pence	13 pence
One tonne of virgin material saved	41 pence	14 pence	8 pence
One tonne of hazardous waste eliminated	£11	£4	£2
One tonne of water reduced	41 pence	14 pence	8 pence
One £ cost savings	3 pence	0.8 pence	0.5 pence
One £ additional sales	2 pence	0.7 pence	0.4 pence

Note: As of July 14, 2016, one British pound (100 pence) was equivalent to \$1.72 CAD.

Additional Insight

The Pathway report presents some additional insights with respect to the NISP model. For example, the report notes that there were 60 practitioners across 13 regions, giving some indication of the scale of the operation. Furthermore, the report notes that in 5 years, 12,500 businesses were engaged, the majority of which were surprisingly small and medium-sized enterprises (SMEs). The report also introduces the role and importance of regional Program Advisory Committees comprising mainly business representatives. Lastly, the report underscores the diverse resource streams and business sectors that the program engaged.

Green Game-Changing Innovation: New Business Thinking From Around the World, 2010

This report may be found in Appendix E.

See also http://assets.wwf.org.uk/downloads/greengamechange_report.pdf

The World Wildlife Fund-UK (WWF-UK) commissioned a study to highlight commercial innovations and show how companies are benefiting from sustainable business opportunities. The study was completed by Verdantix.

Following a market scan, 120 global innovations were identified. These were screened against the following criteria (p. 5):

Is it **relevant**? Does the innovation provide significant benefits across one or more dimensions of environmental sustainability: energy efficiency, the decarbonisation of energy, water efficiency, ecosystem health (or services)? Has it achieved some adoption already, or is it close to reaching the market?

Does it have the potential to be **game-changing**? Is it scalable with the potential to achieve a high level of market adoption? Is it likely to achieve lasting adoption? Is it sufficiently different in nature from existing market offerings? Does it have the potential for a high commercial impact? Could it change the competitive landscape? Could it alter existing markets and create new ones?

Facilitated industrial symbiosis, as represented by NISP-UK was ranked one of the top 20 global innovations for business sustainability. The report notes that “[I]ndustrial symbiosis programmes can facilitate partnerships that generate mutual value and improvements in resource efficiency, cost savings and new revenue. ...This model is applicable worldwide.”

Global Green Growth Forum (3GF) Industrial Symbiosis Partnership

The 3GF Industrial Symbiosis Partnership reports may be found in Appendix F.

The Danish Government, supported by the Governments of Korea and Mexico, established the 3GF in 2011, to demonstrate how public and private sector collaboration could drive long-term green growth.

The current Advisory Board is listed below:

Co-Chairs:

- Seunghoon Lee, Co-Chair of the Green Growth Committee of the Government of the Republic of Korea

- Danfoss, Niels B. Christiansen, President & CEO
- Governments:
- Government of Denmark, Kristian Jensen, Minister for Foreign Affairs
 - Government of the United Mexican States
 - Government of the People's Republic of China
 - Government of Qatar
 - Government of Kenya
 - Government of the Federal Democratic Republic of Ethiopia

Companies:

- ABB Denmark, Claus Madsen, CEO
- Alstom, Giles Dickson, VP Environmental Policies & Global Advocacy
- Banco Nacional de Mexico (Banamex /Citygroup), Ernesto Torres Cantú, CEO
- Bidco Group & Kenya Private Sector Alliance and East African Business Council, Vimal Shah, CEO & Chairman
- Hyundai Motors, Woong-Chul Yang, Vice Chairman
- McKinsey & Co., Jeremy Oppenheim, Director
- Novozymes, Peder Holk Nielsen, President & CEO
- Samsung C&T Corporation, Chi Hun Choi, CEO

- Siemens Denmark, Jukka Pertola, President & CEO
- Trina Solar, Jifan Gao, Chairman & CEO
- Vestas, Anders Runevad, CEO

International organisations:

- International Energy Agency, Maria van der Hoeven, Executive Director
- International Finance Corporation, Jin-Yong Cai, CEO
- Organisation for Economic Co-operation and Development, Angel Gurría, Secretary General
- UN Global Compact, Georg Kell, Executive Director
- Climate Policy Initiative, Tom Heller, Executive Director
- Global Green Growth Institute, Yvo de Boer, Director-General
- World Resources Institute, Andrew Steer, President & CEO
- Inter-American Development Bank, Luis Alberto Moreno, President
- Centro Mario Molina, Juan Carlos Belausteguigoitia Rius, Executive Director

The 3GF established an Industrial Symbiosis partnership at its 2013 forum. It notes:

“Industrial symbiosis is a key driver of green growth. It has been recognised across the world for its contribution to the circular economy through green growth, eco-innovation, job creation and resource efficiency. The vision shared by 3GF’s IS PPP partners is to deliver a model of IS that works at scale, integrating within and across country boundaries to optimise the potential for IS to address global agendas.”

The Industrial Symbiosis partnership has estimated that global scale-up of the NISP model could generate around \$7.7 billion USD per annum in benefits from an estimated annual investment of only \$213 million USD.

The Industrial Symbiosis partnership was instrumental in successfully lobbying the G7 to establish its Alliance for Resource Efficiency at the 2015 G7 Summit. The Industrial Symbiosis partnership has also supported the launch of NISPs, such as the Western Cape Industrial Symbiosis Program in South Africa, and convened a 3GF Regional Conference in Africa in 2015, with a focus on emerging industrial symbiosis activity in Africa. Subsequently a European Switch Africa Green project is supporting industrial symbiosis in South Africa, Kenya, Ghana, Burkina Faso, Mauritius and Uganda whereas the African Development Bank is supporting such work in Egypt.

Economic Analysis of Resource Efficiency Policies, 2011

The full report may be found in Appendix G.

This report was commissioned by the European Commission Directorate General for Environment (“DG Environment”) and prepared by COWI Consultants of Denmark, an 85-year old engineering, economics and environmental science consultancy with more than 6,000 employees. Their final report, titled “Economic Analysis of Resource Efficiency Policies” screened 120 programmes from 23 countries. Using evaluation criteria such as the scale of resource efficiency potential; sector coverage; resource coverage, nine programmes, including NISP, were selected for further analysis. NISP scored top for cost effectiveness, impact and replication potential across Europe and was said to provide “...the widest environmental and economic benefits” and “...optimises the use of resources”. The authors noted that NISPs success was supported by “... cross sectoral synergies between industries...” and “...backing of national funding...”. COWI also posited that “EU-wide network has the potential to be even more successful than NISP in England”, but noted that funding can be a limiting factor.

Based on the findings of this report, the EU funded NISP projects in Romania and Hungary. In Romania, the EU is provided 42% of a total €880 700 (~ \$1.28M CAD) funding required for a two-year regional program that ran from February 2009 to October 2011. In Hungary, the EU provided 50% of the €800 000 (~\$1.16M CAD) costs for a three-year program that began in 2010.

Circular Economy in Europe: Developing the Knowledge Base, 2016

This report may be found in Appendix H.

This report was published February 2016 by the European Environment Agency, an agency of the European Commission. The report lists industrial symbiosis as a key enabling business model to advance the circular economy, with the NISP-UK presented as a case study.

The report is part of a larger European Action Plan for the Circular Economy, which will support the EU’s efforts to develop a sustainable, low carbon, resource efficient and competitive economy by protecting businesses against the scarcity of resources and volatile prices.

The Council of the European Union adopted conclusions for action for a circular economy that (June 2016):

(3) CONSIDERS the active involvement of the private sector and other stakeholders across Europe and at the global level a key element for a successful and more effective transition towards a Circular Economy; ENCOURAGES the EU and the Member States, at all levels of government, to actively engage the private sector to promote cooperation, innovation and industrial symbiosis projects within and across sectors and value chains; including by addressing specific challenges in the transition to the Circular Economy, through agreements between stakeholders in society and governments ...

Canadian National & International Policy Alignment

Draft Federal Sustainable Development Strategy, 2016

A detailed document analysing the alignment of the NISP model with the Draft Strategy may be found in Appendix I.

The Draft Federal Sustainable Development Strategy (Draft FSDS) was tabled in 2016 to “...set the federal government’s environmental sustainability agenda for the next three years.” The Draft FSDS sets out a number of goals and targets under five overall headings, of which two, *Taking Action on Climate Change* and *Clean Technology, Jobs and Innovation* are particularly relevant to NISP.

The NISP model, and delivery of any ‘NISP-Canada’ will help the federal government achieve many of its goals and targets, especially with respect to Taking Action on Climate Change, and Clean Technology, Jobs and Innovation. For example, one of the Taking Action on Climate Change targets is “National Leadership on Climate Change: Relative to 2005 emission levels, reduce Canada's total GHG emissions 17% by 2020 and 30% by 2030”, with a proposed initiative supporting “Voluntary sustainable development actions to reduce GHG emissions”. Based on international experience, a NISP-Canada could engage at least 120 businesses per year, per region in voluntary, profitable actions to reduce GHG emissions. The NISP model would provide businesses with a tried and tested tool, capable of benefiting their businesses while reducing GHG emissions.

As detailed in Appendix I, the NISP model appears to support 17 proposed initiatives corresponding to eight of the Draft FSDS targets.

COP21, 2015

The Pathway to a Low Carbon Economy Report (discussed at the start of this section) verified that industrial symbiosis as delivered through the NISP model reduces greenhouse gas emissions through six different methods:

1. Inputs: Lower embedded energy in processing recycled materials than extracting virgin raw materials
2. Processes Savings: in gas, electricity and other fuel use by synergy partners, principally through innovation
3. Fuels substitution: Replacing fossil fuels with other fuel sources in industrial processes
4. Transport Reduction: in transport directly related to implementation of local synergies
5. Disposal Reduction: in reducing biodegradable material sent to landfill
6. Energy Production: of energy through, for example, anaerobic digestion and utilisation of waste heat

The NISP model could help Canada work towards its international greenhouse gas emission reduction commitments in a manner that mobilizes the private sector and creates economic benefit for both the private and public sector (as outlined in the Pathway to a Low Carbon Economy report).

G7 Alliance for Resource Efficiency (G7-ARE), 2015

The Annex referencing the creation of the G7-ARE, as well as the G7-ARE Industrial Symbiosis Workshop Report may be found in Appendix J.

The Group of Seven (G7) represents the United States, Canada, France, Germany, Italy, Japan, and the United Kingdom. The G7 members meet formally on an annual basis to discuss and collaborate around global issues.

At its 2015 Summit, the G7 reaffirmed “...the high importance of the protection and efficient use of natural resources throughout their life cycle and the positive impact on all three equally important dimensions of sustainability – economic, environment and social aspects.” (Annex, p.8) and established a “...G7 Alliance on Resource Efficiency, which will provide a forum to exchange and promote best practices and foster innovation together with business (Business 7) and other stakeholders, including from the public sector, research institutions, academia, consumers and civil society, on a voluntary, non-binding basis” (Annex, p. 8).

The very first action of the G7-ARE was to convene an international Workshop on Industrial Symbiosis, held on October 29th/30th, 2015, in Birmingham, UK, the ‘birthplace’ of the NISP model. In recognition of the success of the NISP model, the G7-ARE invited the creator of the NISP model, Peter Laybourn of International Synergies Ltd., to develop the program and background materials for participants. As the meeting coincided with the transition period of the Canadian federal government, Canada was only able to send one participant as an observer. The goal of this gathering was to share best practices and to endorse and support the implementation of industrial symbiosis on an international scale.

United Nations Sustainable Development Goals

See <http://www.un.org/sustainabledevelopment/sustainable-development-goals/>

Industrial symbiosis supports several of the United Nations’ Sustainable Development Goals and targets:

Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all

Target: Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour intensive sectors

This target is supported by Industrial symbiosis as synergies among industries promote innovation that reduce the amount of raw materials used. Shifting towards increased product value and reparability also reduces consumption of goods and resources.

Target: Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services

Counterintuitively, there has been significant participation of SMEs in NISPs worldwide. The UK participation of SMEs is documented in the Pathways to a Low Carbon Economy report, which further found that 20% of implemented symbiosis opportunities involved some level of innovation.

Target: Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the

10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead

This target is supported by Industrial symbiosis as synergies among industries promote innovation that reduce the amount of raw materials used. Shifting towards increased product value and reparability also reduces consumption of goods and resources.

Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation

Target: By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.

NISPs target existing industries; therefore, NISPs catalyse retrofit activities. The resulting symbiosis partnerships increase materials, energy, and/or water resource-efficiency. 20% of the resulting symbiosis partnerships involve some level of clean technology innovation.

Goal 11: Make cities inclusive, safe, resilient and sustainable

Target: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

NISP initiatives have been proven to significantly reduce the amount of solid waste requiring landfill; the use of hazardous wastes; industrial water consumption; energy consumption; and greenhouse gas emission generation. These impacts are on a regional or metropolitan area scale.

NISP-CANADA: FEASIBILITY CONCLUSION

The NISP Model is Feasible

The NISP model has been independently evaluated; independently audited; and proven to be adaptable, as it is now operating in more than 20 countries. The feasibility of the NISP model has been well-demonstrated internationally.

The NISP model supports Canadian policy goals and is feasible in the Canadian context.

The NISP model has been **independently evaluated**. It has been identified by several organizations, including the Global Green Growth Forum, EC Directorate General for the Environment, and World Wildlife Fund, as being one of the top international best practices for achieving resource efficiency and fostering sustainable business activity.

The NISP model has been **independently audited**. Its methodologies for calculating the benefits from implemented symbiosis opportunities has been verified, and the scale of benefits achieved in the UK has been confirmed. The NISP model has proven, measurable benefits such as reducing greenhouse gases, reducing waste materials to landfill, strengthening businesses competitiveness, creating jobs, and building skills and capacity to support a circular, low carbon economy.

The NISP model has **proven to be adaptable**, with initiatives based on the model now running in 21 countries. As the NISP network has grown, the framework has proven itself adaptable to different geographies and financial models. NISP has proved its flexibility to being adapted to many contexts, with varying geographical or financial conditions. For example, in Holland where there is only one central industrial region, NISP becomes a singular regional program, whereas in Turkey, with multiple industrial regions under largely national control, an expansive program was rolled-out in a short-period of time, regionally delivered and nationally funded and orchestrated. Holland funds the program solely on government funds, whereas Belgium is half funded by government and the chemical industry.

The NISP model **supports Canada's national and international policy commitments**. Therefore, the Canadian government, and, provincial and municipal governments, should support the establishment of a NISP in Canada. The NISP model supports several of the federal governments targets related to goals for tackling climate change and advancing clean technology outlined in the Draft Federal Sustainable Development Strategy. The NISP model also supports Canada's international commitments made under COP21, the G7 (via its Alliance for Resource Efficiency) and the United Nations Sustainable Development Goals.

The verified success, and proven flexibility and adaptability indicates that NISP should be as feasible in the Canadian context as it has proven successful in the 20 other jurisdictions to-date.

NISP Model: Considerations for Canadian Adaptation

The Canadian context does raise some unique organizational questions that must be answered before the model can be readily replicated in regions across Canada. These questions, and a possible plan for addressing them, are presented below. Given the nature of the questions, and the challenges in general with respect to national co-ordination across a federation structure, we recommend that NISP be adapted to Canada in two or more regional pilots first. Such pilots would help to answer these questions, and would shape a 'Made in Canada' NISP initiative.

HOW BIG IS A 'REGION'?

A metropolitan area? A province? It is not clear how far and wide the generally minimum two regional practitioners could reach. It is also not clear how far businesses would travel to attend a workshop, or at what scale geography begins to present a common barrier to an otherwise viable symbiosis business case. Any pilots will seek to provide a better understanding of business participation rates and businesses' need for practitioner assistance in advancing the symbiosis opportunities identified at the workshop.

HOW MANY AND WHAT REGIONS ARE DESIRABLE FOR A NATIONAL PROGRAM?

The UK program was ultimately delivered across the whole of England in 13 regions, following the boundaries of its regional economic development authorities. Falling out of the unknowns related to the required size of a Canadian region, it's not known how many regions should be included in a Canadian national program. For example, should a 'national' program in Canada focus on the metropolitan areas around cities represented by the Big City Mayors' Caucus, or include other regions as well?

WHAT ARE THE OPTIONS FOR FINANCING THE PROGRAM?

The international precedent is generally for the majority of funding/investment to come from national (or EU) government sources. In the short to medium term, investing in a 'NISP-Canada' is an attractive value proposition for policy makers /governments who are already investing significant amounts to achieve the combined aims of job creation, growth, innovation, competitiveness, and greenhouse gas emission reduction.

Long-term, it is not likely politically palatable for a NISP-Canada to be primarily funded by the federal government. Long term funding will be greatly influenced by the results of any pilot. For example, it's possible that, like Belgium, certain sectors see great success and those associations are therefore incentivized to fund the program long term. Alternative finance mechanisms should also be explored, such as green bonds, social impact bonds, and the establishment of a trust into which a portion of companies' savings from implementing symbiosis could be deposited and used to sustain the program. The European Commission's Directorate General for the Environment commissioned a report in 2011 that, while endorsing the NISP model, did note that scaling could be affected by limited funds (Economic Analysis of Resource Efficiency Policies, 2011, see also Appendix G). Should Canada be able to develop some alternative funding models, there would likely be significant international interest in learning from and adapting these models to other NISP initiatives.

It should also be noted that, to secure government funding, both the Canadian and provincial contexts would likely require NISP to be housed within a not-for-profit entity. However, this should also be confirmed during any pilot.

HOW DO THE BENEFITS SEEN IN THE UK SCALE TO A CANADIAN REGION?

And what might that mean for benefits in other regions in Canada? The geographic, regulatory, and economic landscape is not only unique at the national scale, but also varies regionally as well. It's not known how the benefits scale to regions with less heavy industry, or what the influence is, if any, of policies such as a carbon tax or strong extended producer responsibility legislation.

In conclusion, while it is most certainly feasible to apply the NISP model in the Canadian context, there are some considerations that may shape the final form of any NISP-Canada. Regional pilots would help to answer outstanding questions. The answers to these questions will: maximize the success of a regional model; shape a sustainable, multi-region "Made-in-Canada" program; and provide yet another valuable case study to the growing number of countries exploring how best to adopt NISP to meet their national and local sustainable business objectives.

References

DG Environment (2011). *Economic Analysis of Resource Efficiency Policies*. Version 1.2

European Environmental Agency (2016). *Circular Economy in Europe: Developing the knowledge base*. ISSN 1977-8449

G7 Alliance for Resource Efficiency (2015). *Annex to the Leaders' Declaration G7 Summit*. 7-8 June 2015, Schloss Elmau.

G7 Alliance for Resource Efficiency (2015). *Workshop on Industrial Symbiosis*. 29/30 October 2015 Birmingham City Council House, Birmingham UK.

International Synergies Ltd. (2005-Present). *Compilation of selected Case Studies*.

International Synergies Ltd. (2009) *National Industrial Symbiosis Program: The Pathway to a Low Carbon Sustainable Economy*.

International Synergies Ltd. (2016). *South Africa: Breakdown of data and achievements*.

Light House Sustainable Building Centre (2016). *National Industrial Symbiosis Program (NISP) Model Supporting Canada's Sustainable Development Goals*. Based on Draft Federal Sustainable Development Strategy, February 2016, accessed at <http://fsds-sfdd.ca/index.html#/en>

The Global Green Growth Forum (3GF) (2015). *3GF Partnership: Industrial Symbiosis*.

The Global Green Growth Forum (3GF) (2015). *Partnership Session Summary: Industrial Symbiosis*. 3GF Africa Conference 2015.

The Global Green Growth Forum (3GF) (2013). *Report: Improving Resource Efficiencies*. Global Green Growth Forum 21-22 October 2013, Copenhagen.

National Cleaner Production Centre, South Africa. (2015). *Gauteng Industrial Symbiosis Programme (GISP) Summary Report*. Available online at <http://sawic.environment.gov.za/documents/3946.pdf>

Scott Wilson Business Consultancy (2016). *National Industrial Symbiosis Programme (NISP): Economic Valuation Report*.

WWF-UK. (2010). *Green game-changing innovation: New business thinking from around the world*.

APPENDIX A

Workshop Outcome Report

APPENDIX B

South Africa: Breakdown of data and achievements

APPENDIX C

Case Studies



APPENDIX D

NISP Economic Valuation Report, 2009 Pathway to a Low Carbon Sustainable Economy, 2010

APPENDIX E

Green Game-Changing Innovation: New Business Thinking From Around the World, 2010

APPENDIX F

Global Green Growth Forum (3GF):

3GF Partnership – Industrial Symbiosis

Partnership session summary- Industrial Symbiosis

Improving Resource Efficiencies in the Value Chain

APPENDIX G

Economic Analysis of Resource Efficient Policies, 2011

APPENDIX H

Circular Economy in Europe: Developing the Knowledge Base, 2016

APPENDIX I

NISP Federal Sustainable Development Goal Alignment



APPENDIX J

G7 Alliance for Resource Efficiency: Workshop on Industrial Symbiosis 29/30 October 2015

Washington Industrial Waste Coordination (Industrial Symbiosis)

Program Recommendations

Appendix C: NISP[®] Canada Performance Report



NOVEMBER 2019

LIGHT HOUSE SOCIETY

**with International Synergies Ltd.
and Center for Sustainable
Infrastructure**

PREPARED FOR

**Washington State Department of
Commerce**





TURN WASTES INTO VALUABLE RESOURCES

BE PART OF THE CIRCULAR ECONOMY

DELIVER ON GOVERNMENT PRIORITIES

Advancing a Circular Economy in Canada:

National Industrial Symbiosis Program (NISP®) Canada Pilot Project, Metro Vancouver & Greater Edmonton

Final Report

June 15, 2019





With special thanks to the NISP® Canada Pilot Funders:



Western Economic
Diversification Canada



metro
vancouver

Edmonton



CITY OF
SURREY
the future lives here.



innovate BC



BRITISH
COLUMBIA



NEW WESTMINSTER

We would like to acknowledge the following special NISP® Canada champions for their faith and support behind-the-scenes as the NISP® pilot took shape and role in delivering the pilot:

Jennifer Teskey, Senior Business Officer, Western Economic Development; **Jason Emmert**, Senior Planner, Air Quality and Climate Change, Planning & Environment, Metro Vancouver; **Joshua Power**, Climate Policy Analyst, Air Quality and Climate Change, Planning & Environment, Metro Vancouver; **Ken Mamczasz**, Director, Economic Investment and Development, Urban Form and Corporate Strategic Development, Economic and Environmental Sustainability, City of Edmonton; **Liam McClellan**, Principal Planner, Economic Investment and Development, Urban Form and Corporate Strategic Development, Economic and Environmental Sustainability, City of Edmonton; **Rob Costanzo**, General Manager, Corporate Services, City of Surrey; **Harry Janda**, Solid Waste Manager, City of Surrey; **Norm Connolly**, Community Energy Manager, City of New Westminster; **Kailyn Skuban**, Program Manager, Ignite, Innovate BC; **Mark Raymond**, Manager, Resource Management Unit, BC Ministry of Agriculture; **Jake Turek**, Waste Management Engineer, BC Ministry of Agriculture; **Janice Larson**, former Executive Director, Regional Innovation Initiatives BC Ministry of Technology, Innovation and Citizens' Services (Retired); **Lindsay Bisschop**, Manager, Partnerships & Outreach, Sector Development Branch, BC Ministry of Agriculture; **Neil Dobson**, Executive Director, Clean BC Implementation, Province of BC; **Vanessa Timmer**, Executive Director and Co-Founder and **Dagmar Timmer**, Managing Director, Strategic Initiatives and Co-Founder, One Earth; **Chris Bush**, President, Catalyst Agri-Innovation Society; and; **Paul Shorthouse**, BC Regional Director, Delphi Canada.

With extra special acknowledgment of

Ted Sheldon, Senior Clean Energy Advisor | Alternative Energy | Ministry of Energy, Mines, and Petroleum Resources (Retired) who provided much strategic advice as well as energetic and unending support including acting as the point person for the cross-departmental Province of BC staff team; **Nadine Diner**, Director of Industry Initiatives, Industry and Innovation Group, Innovate BC, also for her (years) of energetic and unending support and strategic advice; and **John Holland**, Chief Development Officer, Pinchin Ltd. & President, Light House Board of Directors for backing Light House's years of in-kind effort building and securing funding for the NISP® Canada pilot.

The NISP® Canada pilot's success is owed to our delivery team:

Timo Makinen, Director of Operations who also fearlessly led the program during the Managing Director's unexpected several month medical leave; Practitioners **Margaret Hrehoruk**, **Liz Gandy**, **Amir Hagpanahi**, **Hilal Savas**, and **Hannah Macdonald**; **Nessim Boudghene**, Communications & Outreach Co-ordinator; **LeAnn Mogerma**n, Controller; **Peter Laybourn**, Chief Executive, International Synergies Ltd.; and **James Woodcock**, International Manager, International Synergies Ltd.

This report was prepared by Tracy Casavant, Managing Director, NISP® Canada & Circular Economy, Light House

© 2019 Light House Sustainable Building Centre Society.

Exclusive rights to reuse this report in whole or part assigned to funders listed above. All other rights reserved

Executive Summary: National Industrial Symbiosis Program (NISIP®) Canada Pilot Performance Report

Industrial Symbiosis transforms: 'waste' resources into value-added inputs for other business. Industrial Symbiosis is a key, *practical* means for shifting businesses to a low carbon, circular economy.

Circular business models will gain an ever greater competitive edge in the years to come because they create more value from each unit of resource than the traditional linear 'take-make-dispose' model. Accelerating the scale-up promises to deliver substantial macroeconomic benefits as well as open up new opportunities for corporate growth. World Economic Forum 2014

Our feasibility study¹ concluded that the UK-developed NISIP® model achieves the most industrial symbiosis in the shortest amount of time. The NISIP® model is delivered regionally; uses facilitation to engage businesses and identify symbiosis opportunities; requires regionally-based practitioners dedicated to helping businesses implement symbiosis. There is no cost for businesses to participate in workshops or access NISIP® practitioners.

The NISIP® model supports UN Sustainable Development Goals

- ✓ Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all
- ✓ Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation
- ✓ Goal 11: Make cities inclusive, safe, resilient and sustainable

Delivering the NISIP® Canada Pilot

Although the NISIP® model had been adapted to 35 countries, Canada's unique geography, federal structure resulting in multiple environmental regulatory jurisdictions, and SME-dominated economy raised questions regarding the applicability and achievable benefits in Canada. So, a pilot was required.

NISIP® Canada was piloted in the Metro Vancouver and Greater Edmonton regions for 20 months (Oct 2017-May 2019) pilot, including 6 facilitated workshops and the retention of 2 full-time practitioners **per region**. The pilot was a program of Light House Sustainable Building Centre, a Vancouver-based not-for-profit. The pilot was funded by Western Economic Diversification, Metro Vancouver, City of Edmonton, City of Surrey, City of New Westminster, Innovate BC, BC Energy & Mines, BC Ministry of Agriculture, and BC Citizen Services and Community Development (now BC Municipal Affairs).

¹ National Industrial Symbiosis Program Model Feasibility Study for Canadian Adaptation. Light House Sustainable Building Centre Society. 2016.

The NISIP® Canada pilot was a great success!



Already \$6.3M in cost savings and/or new revenues for participating businesses

Government ROI of 7 to 1.

Awesome initiative with a huge potential to help organizations to divert more from the landfill.
- M. Capriles, Goodwill Industries of Alberta

1,900 potential material, water, or energy 'waste' resources id'd to date

253,800 tonnes of waste diverted from landfill.



IS presents a great opportunity to reduce our ecological footprint while improving our business efficiency. – J. Thwaites, LUSH Cosmetics



23,800 tonnes of CO_{2e} emissions avoided¹, equivalent to more than 5,000 passenger vehicles driven for one year¹

Fantastic concept. Great for industry. - C. Kiff, Kruger Products

350+ businesses engaged, starting 'from scratch' in terms of regional business awareness of the model and pilot!



Selected Outcomes by Region

Outcome	BC	AB
Additional Sales	\$236,600	\$1,269,600
Cost Savings	\$171,600	\$4,670,100
Total Direct Economic Benefit	\$408,200	\$5,939,700
GHG Emissions Avoided (tonnes CO _{2e})	12,900	11,000
Waste Diverted to Landfill (tonnes)	2,600	251,200
Industrial Water Savings (m ³)	1,000	1,152,000
# Resources Identified	2,302	1,824
# MWE Resources Identified	950	952

Given that only 160 out of more than 3,500 potential matches have been actively nurtured by practitioners so far, and we are still awaiting data from many of those, **the benefits from NISIP® Canada could be far, far greater.**

The NISIP® Canada pilot was a success. NISIP® Canada should continue, as it catalyses profitable private sector circular, low carbon economy activity with no new regulations required.

The pilot demonstrated the **importance of facilitated industrial symbiosis**; The NISIP® Canada practitioners were a crucial element of success, working directly with businesses to help them evaluate and implement their opportunities.

NISIP® Canada now stands as an exemplary demonstration of regional, provincial, and national action on the low carbon, circular economy agenda.

Governments at every level should continue to support NISIP® Canada's valuable contribution to Canadian efforts to tackle our global climate and ecological crises.

Selected Symbiosis Case Studies²

Theatrically Heating Students

Great Northern Way Scene Shop (GNWSS) is one of Metro Vancouver's most significant producers of sets for regional theatre, opera, and film sets, generating clean wood waste which currently goes to landfill. Practitioners identified a match between GNWSS's wood waste and **BCIT's** new wood-fired district heating system. Once BCIT's new boiler is purchased and installed (estimated late 2019), GNWSS wood waste will begin heating students (buildings) at BCIT! This synergy is highlighted in a [video](https://vimeo.com/277699619) (<https://vimeo.com/277699619>) produced by Metro Vancouver, showcasing NISP@ Canada.

Fashion-friendly Tissue

Kruger Products produces facial tissue at its New Westminster plant. They achieved FSC® certification in 2011, the first tissue company in Canada to do so. **Fabcycle** operates firmly in the circular economy, collecting textile waste from apparel production and facilitating its reuse. Fabcycle was seeking heavy duty tubes to help organize the textiles in the storefront. During a site visit to Kruger, a NISP@ practitioner noticed cardboard tubes in the waste bin, resources which weren't originally tabled at a workshop. The practitioner was able to broker the transfer of tubes from Kruger to Fabcycle.

Pallets are Paramount in Edmonton

Paramount Pallet is the largest provider of pallets, including recycled pallets, in Canada. **Paramount Pallet** has collected used pallets from **The City of Edmonton, Shell Canada's Scotford Complex, GEEP Canada, Goodwill Industries, and Univar Canada.** Univar saved \$3,000 in disposal costs. Shell provided 1,200 pallets, diverting 3 truckloads from landfill. For GEEP, this synergy utilizes 12 trucks full of pallets or 142 tonnes of wood. Paramount was able to clean and repair the 1,172 tonnes of pallets collected from these partners so far, representing \$14,000 in new revenues. More synergies are pending!

Getting an Energy Boost from (Waste) Coffee

Tim Horton's (Devon) is a franchise operation for the iconic Canadian doughnut and coffee shop. The location generates food waste, including significant quantities of coffee grounds. One of **EcoGrowth's** technology developments is a waste-to-energy system that runs on biomass. **EcoGrowth** collected 1 tonne of food waste from Tim Horton's in Devon to test in its technology. If this works, then an EcoGrowth system may be installed at the Tim Horton's to turn waste back into energy (hot water) to use back on site.

Selected Synergies Under Development

Gruger Family Fungi produces a compost-like 'old' fungus material. **Delta Remediation** is testing this waste because it appears as if it could work as an oil absorbent. The potential quantities involved are still confidential, but both parties report that this could result in a significant synergy, not to mention the repurposing of agricultural wastes into a new biobased product.

Urban Granite makes stone counter-tops. While cutting them to size, this process generates stone scrapping calculated in \$3-5 thousand of dollars per month in disposal fees. **Devlin Construction** is evaluating the stone off-cuts to determine if it can crush and reuse them as base road material.

Newlyweds Foods produces herb and spice blends, among other food industry inputs. Its waste streams include a food-grade waxy residue. **Groundstream** is testing this residue for use in its biofuel systems or in its biofuel log production as a biobased binding agent.

A **major chocolatier** generates spent coconut oil, which has the potential to fuel a Renewable Natural Gas facility. With the help of **FortisBC**, the chocolatier will investigate the use of this, and possibly some of its other biobased wastes, to support the growing demand for RNG in BC.

Canadian Mattress Recycling generates waste leather and zippers from furniture recycling. **Our Social Fabric** is investigating collecting the leather and zippers to support its efforts to upcycle used textiles into new products.

Cartem Donuts is investigating the use of this off-spec chocolate from **Emkao Foods** and off-spec blueberries from **Sidhu Farm** as ingredients for its donuts.

NISP@ Canada Knowledge Gained

Canadian businesses keen but extremely busy. NISP@ Canada needs more practitioner site visits to shepherd implementation e.g., sample collection. NISP@ Canada could benefit from more practitioners per region (more funding) and more time between workshops e.g., 3 per year instead of 4.

To better engage manufacturers NISP@ Canada struck partnerships with manufacturing associations. 'Manufacturing' has changed rapidly in Canada; we saw participation from new manufacturing types like micro-breweries / micro-distilleries; scrap textile clothing manufacturers; algae-based aquaculture; and value-added cannabis.

Regulations were only cited as a barrier once, and only because of uncertainty in new industries (algae-based aquaculture and cannabis.)

NISP@ Canada regions will generally be smaller than a province. Urban regions will be 50-75 km radii from urban centres. Rural regions will be larger and must be resourced for greater practitioner travel as well as more practitioner site visits.

The NISP@ pilot was run on a **cost-recovery basis** Grant-funding, especially from government, will be the main short-term funding model. However, **it is crucial that government agencies consider that not all low carbon, circular economy solutions involve capital projects; it is difficult for NISP@ Canada to fit in such funding programs, despite its ability to deliver on stated policy objectives.** The NISP@ model lends itself well to alternative financing which will be explored in future



² Specific quantitative outcomes are generally not shown as most companies prefer to have their results confidential and included only in our aggregate outcomes.

Contents

Executive Summary	iii
List of Tables and Figures	vi
Introduction	1
Why Industrial Symbiosis?	1
Why the NISP® Model?	2
Why a NISP® Canada Pilot?	5
NISP® Canada Pilot Delivery	6
Practitioners & Management Team	6
Business Recruitment Process	7
Identifying Potential Synergy (Symbiosis) Opportunities	10
Nurturing Active Synergy (Symbiosis) Opportunities	11
NISP® Canada Pilot Results	13
Economic & Environmental Benefits	13
Cost-Benefit Analysis	14
Synergy Pipeline: Potential Matches	15
Selected Symbiosis Case Studies	16
NISP® Canada Participation	22
Types of Resources Identified	27
Knowledge Gained: Adapting the NISP® Model to Canada:	30
Managing No Shows	30
Recruiting Manufacturing Participants	30
Barriers to Active Synergy Implementation	31
The Canadian Productivity Paradox	33
What is a NISP® 'Region'?	34
Businesses Think Regionally	34
Grant-Based Funding: Essential, But Unsustainable	35
Conclusion	36

List of Tables and Figures

Table 1: Summary of Potential Regional Outcomes Known as of May 30, 2019	14
Figure 1: NISP® Canada Facebook Statistics, Jun 1, 2018 to May 30, 2019	7
Figure 2: Sample NISP® Canada Facebook Postings (Workshop Invite & Related Education)..	8
Figure 3: NISP® Canada Twitter Impressions Dec 1, 2017 to May 30, 2019.....	8
Figure 4: NISP® Canada LinkedIn Page - New Followers Per Month	9
Figure 5: Overview of Potential Matches Per Type, Both Regions.....	15
Figure 6: New Referrals Tracking on NISP® Workshop WANT Sheet.....	22
Figure 7: Distribution of Businesses Attending NISP® Workshops: Metro Vancouver	23
Figure 8: Distribution of Participants Attending NISP® Workshops in Greater Edmonton (excl. Calgary participants)	24
Figure 9: Number of Businesses Having / Wanting Material, Energy, Water Resources Identified, by Category	28
Figure 10: Breakdown of Number of Businesses Having / Wanting Overall Resource Types	29
Figure 11: Barriers to Active Synergy Implementation, By Type (BC+AB).....	31

Appendix A: Workshop Summary Reports

Appendix B: Greenhouse Gas Emission Savings Calculation Methodology

Introduction

Why Industrial Symbiosis?

Governments at every level are tackling challenges related to climate change and solid waste management by working to shift towards low carbon, circular economies.

Industrial symbiosis refers to business-to-business relationships that mimic symbiotic relationships between organisms in nature, where ‘waste equals food’. In practice, industrial symbiosis involves the waste of one or more businesses (or similar government operations, such as a municipal wastewater treatment plant) being diverted to become an input to one or more other businesses. Symbiosis can occur between businesses in the same sector or businesses from different sectors. Industrial symbiosis has grown to include other business-to-business collaboration that captures ‘waste’ or excess resources, such as used equipment, surplus facilities, or even in-house technical capacity, for use by another business that can add new value to the waste. Industrial symbiosis evolved as a theoretical means to achieve better environmental performance, but has proven to be a key, practical means for shifting businesses to a low carbon, circular economy.

Circular business models will gain an ever greater competitive edge in the years to come because they create more value from each unit of resource than the traditional linear ‘take-make- dispose’ model. Accelerating the scale-up promises to deliver substantial macroeconomic benefits as well as open up new opportunities for corporate growth.

World Economic Forum 2014

“[I]ndustrial symbiosis programmes can facilitate partnerships that generate mutual value and improvements in resource efficiency, cost savings and new revenue. ...This model is applicable worldwide.”

Green Game-Changing Innovation: New Business Thinking from Around the World, WWF, 2010

“Industrial symbiosis is a solution ready to be scaled...the potential global impact of large scale industrial symbiosis could be around US\$7.7 billion per annum from an annual investment of only US\$213 million.”

Global Green Growth Forum, 2015

Why the NISP® Model?

As discussed in the NISP® Canada feasibility study³ and excerpted here, industrial symbiosis can be catalysed in four key ways:

1. **Serendipity:** Isolated examples of industrial symbiosis that was implemented by two businesses with no external help e.g., the businesses met by chance and recognized a specific opportunity.
2. **Passive Engagement:** Waste exchange databases that allow businesses to enter their waste materials and / or search for input replacements. Sometimes supported by a co-ordinator who keeps an eye open for opportunities, or who might connect businesses to resources needed to implement the transaction e.g., a transportation company.
3. **Data-Driven:** Third-parties visit companies and collect data via surveys, interviews, and waste audits. The third-parties then review the data to look for opportunities. Businesses are provided with just the recommendations, or the third-party is resourced enough to spend time trying to convince the businesses to implement them.
4. **Facilitated:** Businesses are engaged as a group, such as in a workshop, where a facilitator helps to identify potential symbiosis opportunities by drawing out businesses' resource stream haves and wants. Facilitators then follow-up with businesses to help them implement the opportunities.

Our pre-pilot feasibility study⁴ concluded that **the facilitation-based, UK-developed NISP® model achieves the most industrial symbiosis in the shortest amount of time.** The award-winning NISP® model has now been adapted to 35 countries. The NISP® model includes several core elements key to its worldwide success:

- Regional delivery, fostering business relationships across industrial park and local government boundaries;
- Locally-based facilitators (“practitioners”) *dedicated* to nurturing industrial symbiosis opportunities from idea to implementation;
- Identification of a large number of potential symbiosis opportunities, particularly via facilitated workshops;
- Supporting IT Platform (SYNERGie®) ensures that all benefits are accurately quantified; and
- No cost for businesses to participate in workshops or access NISP® practitioners.

³ National Industrial Symbiosis Program Model Feasibility Study for Canadian Adaptation. Light House Sustainable Building Centre June 2016

⁴ *ibid.*

Our pre-pilot feasibility study⁵ found that:

The NISP model has been **independently evaluated**. It has been identified by several organizations, including the Global Green Growth Forum, EC Directorate General for the Environment, and World Wildlife Fund, as being one of the top international best practices for achieving resource efficiency and fostering sustainable business activity.

The NISP model has been **independently audited**. Its methodologies for calculating the benefits from implemented symbiosis opportunities has been verified, and the scale of benefits achieved in the UK has been confirmed.

The NISP model has **proven to be adaptable**, with initiatives based on the model now running in 21 countries. As the NISP network has grown, the framework has proven itself adaptable to different geographies and financial models. NISP has proved its flexibility to being adapted to many contexts, with varying geographical or financial conditions.

The NISP model **supports Canada's national and international policy commitments**. Therefore, the Canadian government, and, provincial and municipal governments, should support the establishment of a NISP in Canada.

The NISP® model advances a low carbon economy by reducing greenhouse gas emissions through six different methods:

1. Inputs: Lower embedded energy in processing recycled materials than extracting virgin raw materials
2. Processes Savings: in gas, electricity and other fuel use by synergy partners, principally through innovation
3. Fuels substitution: Replacing fossil fuels with other fuel sources in industrial processes
4. Transport Reduction: in transport directly related to implementation of local synergies
5. Disposal Reduction: in reducing biodegradable material sent to landfill
6. Energy Production: of energy through, for example, anaerobic digestion and utilisation of waste heat

⁵ *ibid.*

The NISP® model also closely supports several of the United Nations' Sustainable Development Goals and targets, as detailed in the NISP® Canada feasibility study:

Goal 8: Promote inclusive and sustainable economic growth, employment and decent work for all

Target: Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors

This target is supported by Industrial symbiosis as synergies among industries promote innovation that reduce the amount of raw materials used. Shifting towards increased product value and reparability also reduces consumption of goods and resources.

Target: Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services

Counterintuitively, there has been significant participation of SMEs in NISPs worldwide. The UK participation of SMEs is documented in the Pathways to a Low Carbon Economy report, which further found that 20% of implemented symbiosis opportunities involved some level of innovation.

Target: Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead

This target is supported by Industrial symbiosis as synergies among industries promote innovation that reduce the amount of raw materials used. Shifting towards increased product value and reparability also reduces consumption of goods and resources.

Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation

Target: By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.

NISPs target existing industries; therefore, NISPs catalyse retrofit activities. The resulting symbiosis partnerships increase materials, energy, and/or water resource-efficiency. 20% of the resulting symbiosis partnerships involve some level of clean technology innovation.

Goal 11: Make cities inclusive, safe, resilient and sustainable

Target: By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

NISP initiatives have been proven to significantly reduce the amount of solid waste requiring landfill; the use of hazardous wastes; industrial water consumption; energy consumption; and greenhouse gas emission generation. These impacts are on a regional or metropolitan area scale.

Why a NISP® Canada Pilot?

Although the NISP® model had been adapted to many countries, Canada's unique geography and federal structure resulting in multiple environmental regulatory jurisdictions raised questions regarding the applicability of the model in Canada. Furthermore, Canada's economy has very few traditional heavy industrial complexes remaining; instead, the economy comprises largely SMES, albeit generally very modern ones. Many government and private sector stakeholders were uncertain that the benefits seen internationally from the application of the NISP® model could be achieved in the Canadian context. Therefore, a pilot was deemed a necessary precursor to a multi-region, cross-country NISP®.

NISP® Canada was piloted in the Metro Vancouver and Greater Edmonton regions, allowing the model to be piloted in two different environmental policy regimes and in regions with differing economic compositions. Although 24 – 36 month programs are recommended so that results can become more apparent, it was difficult to secure enough resources to sustain a pilot for that duration. Therefore, the NISP® Canada pilot was set for 18 months, and ran from October 2017 to March 2019, including 6 workshops and the retention of 2 full-time practitioners per region.

The pilot was run as a program of Light House Sustainable Building Centre, a Vancouver-based not-for-profit, supported by International Synergies Ltd., the UK-based creators of NISP®. Light House's Vancouver office doubled as 'headquarters' as well as the regional office for Metro Vancouver NISP® Canada

The pilot was funded by Western Economic Diversification, Metro Vancouver, City of Edmonton, City of Surrey, City of New Westminster, Innovate BC, BC Energy & Mines, BC Ministry of Agriculture, and BC Citizen Services and Community Development (now BC Municipal Affairs).

NISP® Canada Pilot Delivery

Practitioners & Management Team

The NISP® model relies on dedicated, generally full-time practitioners to recruit businesses and to identify and nurture symbiosis opportunities. Each region is usually supported by at least one 'senior' practitioner and one 'junior' practitioner. Practitioners are most effective when they combine technical backgrounds and experience with solid problem-solving and communication skills.

Practitioner positions were posted and there was a competitive hiring process. NISP® Canada initially recruited two practitioners per region – one very experienced practitioner supported by a mid-level practitioner in Metro Vancouver, and two mid- to senior- level practitioners in Greater Edmonton. As per NISP® international experience, it was important to retain practitioners with industry experience. Practitioners receive 68 hours of training from International Synergies Ltd UK (ISL), including 40 hours during the week of the first workshop for very hands-on training.

The practitioner team was led by **Timo Makinen, MRM, MBA** (now Director of Operations, NISP® Canada). Timo is a chemical engineer with over 30 years of industry experience with companies such as Shell Canada, BC Hydro, BC Gas (now Fortis BC), and BC Research Inc. Previously, he was the Sustainable Development Manager for Shell's international sulphur and road bitumen businesses. His career experience includes energy project design and planning; energy economics and forecasting; integrated resource planning and DSM; GHG strategy development and implementation; and carbon offset origination and verification.

The NISP® Canada overall pilot was led by **Tracy Casavant, BSc, MES** (now Managing Director, NISP® Canada & Circular Economy). Tracy integrates backgrounds in chemical engineering and environmental studies plus 25 years of industry experience. Tracy has been a leader in the industrial ecology field for 20 years. She co-managed the development of the \$95M TaigaNova Eco-Industrial Park in Fort McMurray and led the original Pearson Eco-Business Zone Strategy to apply industrial ecology to Canada's largest business zone. She has been an invited speaker in Turkey, South Korea, Taiwan, Mexico, Peru, and Ecuador. Tracy also teaches Industrial Ecology in BCIT's Environmental Engineering Technology program.

Technology transfer, training, and technical advisory was provided by **James Woodcock, BSc, BTech**, International Programs Manager, International Synergies Ltd. UK. With over a dozen years of international working experience, James currently manages and delivers Industrial Symbiosis programmes in a number of countries including Belgium, Finland, Germany, The Netherlands, South Africa, Spain and Turkey. Previous projects have also included Brazil, China, France, Ghana, Hungary, Poland, Romania and Slovakia. His responsibilities include project management and delivery to pre-defined targets, training of new and complex concepts

to various audiences (including non-English speaking audiences working with translators), and support of project delivery to in country teams.

Business Recruitment Process

NISP® succeeds because it engages businesses (and similar organizations such as the operational departments of academic and public institutions) of all sizes and across all sectors. The program’s success depends on the participation of businesses; it is important to build general awareness of the program as well as ensure workshop invites reach the right audience.

NISP® Canada delivered general outreach via social media, presentation to business groups, and attendance at industry networking events. Despite the prevalence of social media, individual emails were still the most effective way to secure business participation in a workshop. Presentations and conference networking were also effective, as was mass email distribution via industry association partners, such as the BC Alliance of Manufacturing. On the other hand, social media was effective at raising general awareness and at engaging existing NISP® Canada participants, especially by disseminating their circular economy efforts.

Social Media

NISP® Canada has been utilizing three social media platforms: Facebook, Twitter, and LinkedIn. We have used social media to raise awareness of the program, but also to generally raise awareness of regional, national, and international circular economy activity.

The NISP® Canada Facebook page (<https://www.facebook.com/NISPCanada/>) had more than 200 followers as of May 30, 2019. While the overall audience reach was smaller than Twitter, we found the reach to be more effective, as evidenced by 77 event responses and 36 click-throughs to workshop registration pages as of May 30,2019.

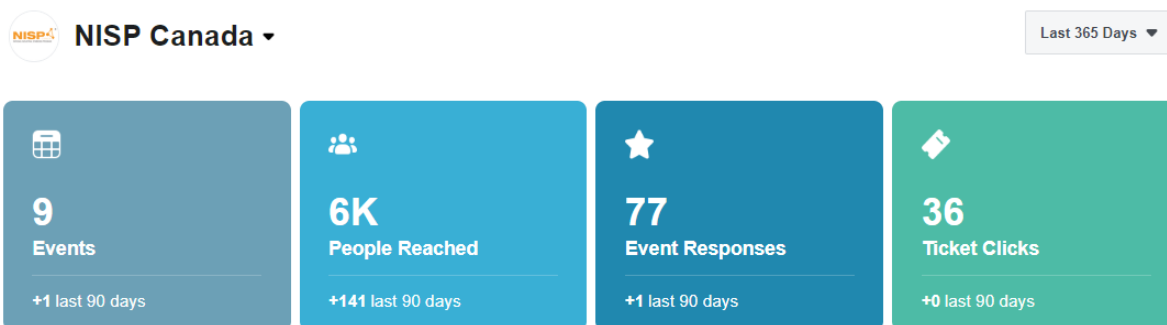


Figure 1: NISP® Canada Facebook Statistics, Jun 1, 2018 to May 30, 2019

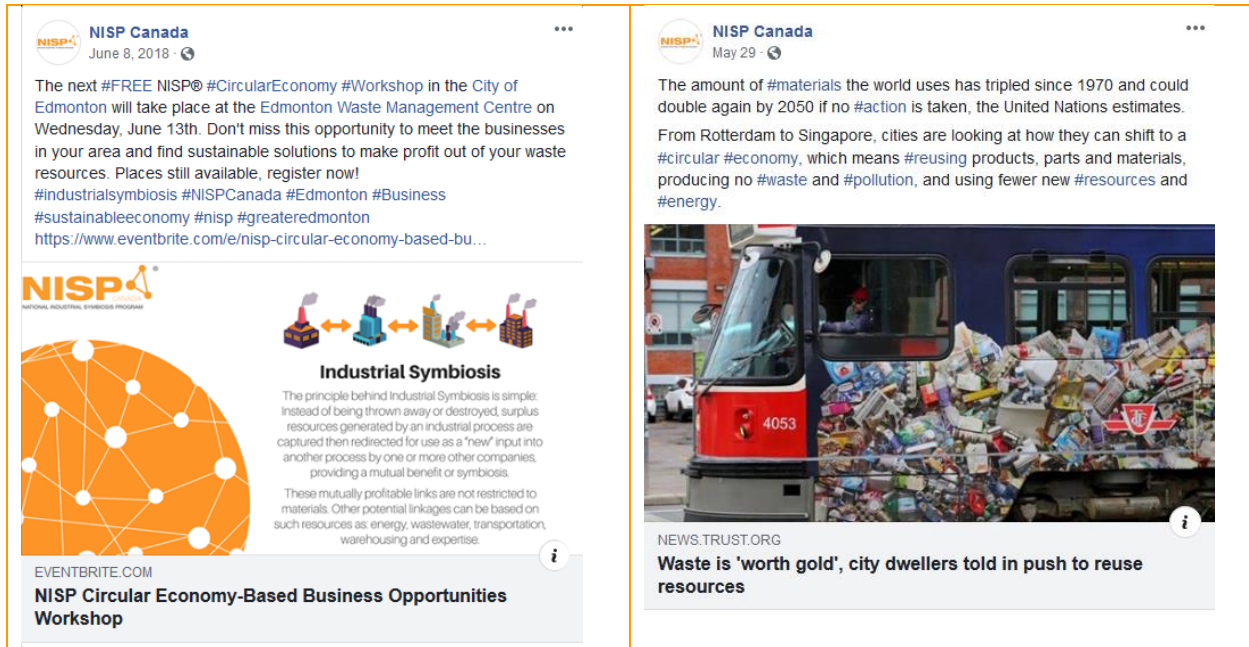


Figure 2: Sample NISP® Canada Facebook Postings (Workshop Invite & Related Education)

The NISP® Canada Twitter account (<https://twitter.com/nispcanada>) now has 301 followers and more than 1,100 direct interactions (Likes). Our overall reach fluctuates, with heavier impressions coinciding with workshop promotion.

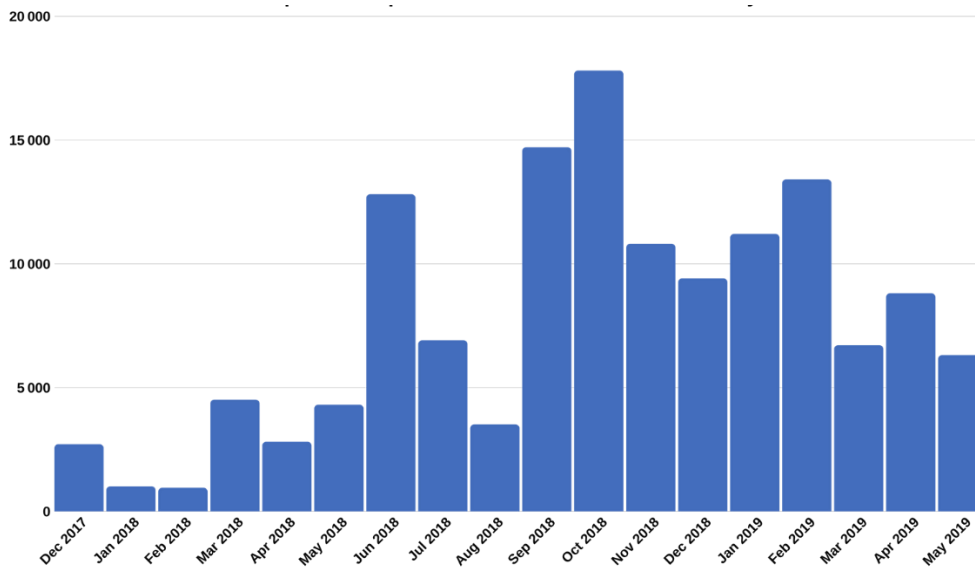


Figure 3: NISP® Canada Twitter Impressions Dec 1, 2017 to May 30, 2019

As the pilot progressed, NISP® Canada began increasingly using LinkedIn, establishing its own page (<https://www.linkedin.com/company/nispcanada/?originalSubdomain=ca>). In addition, NISP® Canada staff found their personal accounts helpful for promoting workshops, targeting workshop invites and general participation, and identifying potential supporters. The number of new LinkedIn page followers per month is shown below. LinkedIn activity tends to increase post-workshop, as participants get more engaged.

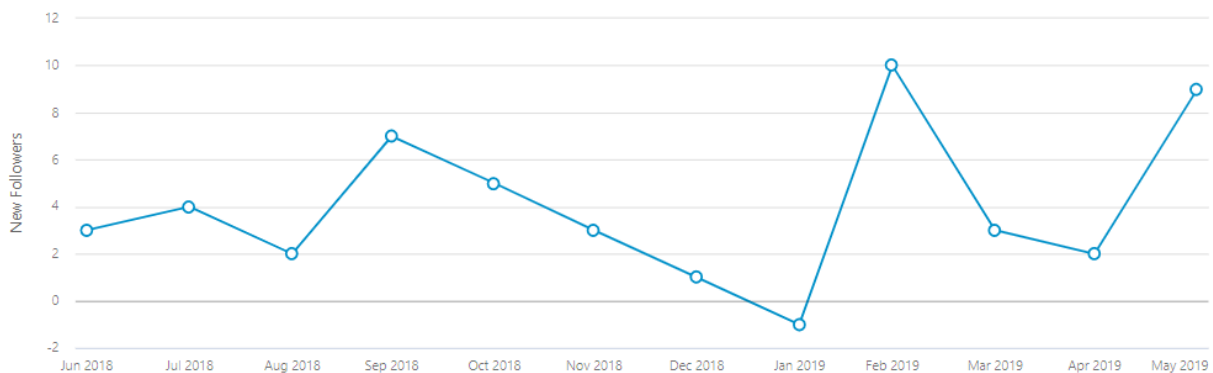


Figure 4: NISP® Canada LinkedIn Page - New Followers Per Month

Presentations, Conferences, and Third-Party Events

NISP® Canada team members participated in a variety of events in an effort to raise awareness and engage businesses generally, as well as to target sectors of interest to program funders e.g., agriculture sector. While presenting was helpful in drawing out potential business participants and future program supporters, we also found that even circulating in trade shows and having one-on-one conversations with exhibitors also helped to increase workshop and program participation. Selected outreach events are listed below:



Timo Makinen, NISP® Canada at the BC Tech Summit

- BC Environmental Industries Association
- BC Environmental Managers Association
- BC Tech Summit
- BCIT Industrial Research Symposium
- Buildex
- Coast Waste Management Association
- Energy Connections
- Environment Canada Circular Economy Experts Roundtable
- Metro Vancouver Sustainability Breakfasts
- National Zero Waste Council
- Pacific Institute for Climate Solutions
- Planet Textiles 9th Annual Summit
- Recycling Council of BC Annual Conference
- Solid Waste Association of North America – Pacific & Yukon Chapter
- UNBC
- Vancouver International Film Festival Sustainable Production Forum
- Western Canada Hemp Industry Conference

Identifying Potential Synergy (Symbiosis) Opportunities

Potential synergies between companies are identified primarily via specially facilitated workshops, especially at the start of the program. However, as the program progresses and the network of participating companies grows, then practitioners play a larger role in identifying potential matches.

The NISP® model is probably most well known for its use of **facilitated workshops** that bring businesses together to tease out potential symbiosis opportunities (workshop “matches”). NISP® Canada delivered 12 workshops in total, 6 per region.

Each workshop also requires volunteer table facilitators and assistants, who each receive 6 hours of training. These volunteer facilitators are drawn from funders, local business champions, local government staff, and other volunteers with suitable background e.g., mature graduate students with industry experience.

Based on the NISP® model, the workshop agenda was generally as follows:

- 8:00 Networking, Registration, Coffee
- 8:30 Opening address (standard overview presentation tailored to local context)
- 9:00 Guest speaker(s) (usually local business champions already practising industrial symbiosis; government supporters, etc.)
- 9:20 Detailed workshop instructions
- 9:30 Coffee break
- 9:50 Haves, Wants & Synergies Working session facilitated according to international protocol
- 11:30 Networking Lunch: During this time, practitioners review working session outcomes.

12:30 Closing Message: Reinforce key messages and collective value; remind businesses they can opt-out of sharing data in the workshop outcome mini-report; close with key highlights from the working session

Ahead of the workshop, businesses are provided with a Workshop Preparation handout to prompt them to begin thinking about resources they have and resources they want. *“In the context of Industrial Symbiosis, it is important that ‘resources’ are recognised in their broadest context. There is a natural tendency to think about waste.... Your outputs may not be waste-related, but could easily be available resources that you can supply to another company as part of an ongoing agreement.”* Businesses are also provided with a worksheet so that they can brainstorm ahead of time what resources they have/ need. The worksheet breaks resources down into the following categories: Materials, Capacity, Energy, Land, Logistics, Water, Expertise.

At the end of each workshop, businesses receive a summary report as well as an individual report summarizing their specific matches and providing contact information for their matches. Workshop summary reports and workshop match matrices have been collated in Appendix A.

As the program progresses and the network of participating companies grows, then practitioners play a larger role in identifying potential matches. Practitioners might identify additional matches by:

- Applying their personal knowledge of resource HAVES and WANTS gained from multiple workshops to match companies from different workshops;
- Visiting businesses (workshop participants, businesses referred by a workshop participant, businesses who have contacted NISP® but were unable to attend a workshop, and businesses identified as potential participants by the practitioners themselves) to expand resource HAVE and WANT knowledge then seeking matches based on their personal knowledge or using Synergie® analysis; and
- ‘Mining’ the Synergie® tool to identify cross-workshop matches.

Nurturing Active Synergy (Symbiosis) Opportunities

Regardless of the origin of a potential match, practitioners must ultimately organize and prioritize potential matches as there are not enough resources (practitioners) to follow-up on all of them simultaneously! Matches are prioritized based on a number of factors. For example, in the early stages of the program, matches that seem quick to implement or those involving high profile or especially keen companies are pursued. As the network grows, and the number of potential matches grows, practitioners can (and need to) apply more stringent prioritization criteria, such as focusing on those matches with high potential landfill diversion, cost savings, or GHG emission reduction. The NISP® Canada networks in Metro Vancouver and Greater Edmonton now have enough critical mass that a more strategic prioritization of matches has begun. This is described in the Types of Resources Identified section.

Matches prioritized for active follow-up become **Active Synergies**. Using the SYNERGie® software platform, these matches are formally advanced to the first stage of an official synergy by assigning the match a Synergy ID and transferring the match from a workshop result to the Idea stage. Synergies progress through five stages:

1. **Idea:** Synergies (previous potential matches) prioritized for follow-up and tracking. Projected, initial estimate outcomes⁶ are entered.
2. **Under Development:** Synergies are moved to this stage once a practitioner starts working with the respective businesses, or if we know the businesses are actively working together to implement the synergy.
3. **Live (Pending):** At this stage, the synergy is happening / has happened, but the outcomes are only estimated not verified.
4. **Live:** The synergy is happening / has happened, *and* the companies have signed off on projected outcomes.
5. **Ended:** The synergy reaches a natural end – either through the resource being depleted (batch transfer), or the contract between the two companies ceasing (be that through commercial decisions or some other reason such as one of the companies going out of business).

Also, at any point, **Barriers** can be logged against any synergy. Barriers can be technical, financial, regulatory (policy), or other. Once the barrier is removed, practitioners can ‘release’ the barrier and progress the synergy in the normal way.

⁶ Outcomes include metrics such as Diversion from Landfill; Revenues Generated; and GHG Emission Reduction.

NISP® Canada Pilot Results

Economic & Environmental Benefits

To date, even if no other potential matches are converted to Active Synergies (see previous section) and if no other data is collected from activated synergies, then implementation of the existing Active Synergies will result in:

\$6.3M in direct economic impact to participating businesses;

**23,800 tonnes of CO_{2e} emissions avoided⁷,
equivalent to more than 5,000 passenger vehicles driven for one year⁸; and**

253,800 tonnes of waste diverted from landfill.

Most workshop participants are unable to provide quantitative information about their resources during the workshop. Outcome data is generally collected manually from the companies, with the accuracy of this data increasing as companies progress from a potential synergy to full implementation. The greenhouse gas emission calculation methodology may be found in Appendix B.

Overall, as we are just beginning to see implementation ramp up, the data for outcomes is limited. However, even based on limited data, the projected program outcomes are significant.

A breakdown of outcomes per region is shown in Table 1 on the following page.

⁷ Based on the NISP® model IPCC-compliant greenhouse gas emissions calculation methodology. Note that the default factors for Grid Electricity were replaced for BC with 0.00001 tonnes CO₂/kWh, reflecting BC's relatively low carbon electricity grid, while the default 0.00064 tonnes CO₂/kWh is being used for AB subject to further input from the Province of AB.

⁸ U.S. EPA Greenhouse Gas Equivalencies Calculator <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

Table 1: Summary of Potential Regional Outcomes Known as of May 30, 2019

Outcome	BC	AB	Total
Additional Sales	\$236,600	\$1,269,600	\$1,506,200
Cost Savings	\$171,600	\$4,670,100	\$4,841,700
Total Direct Economic Benefit	\$408,200	\$5,939,700	\$6,347,900
GHG Emissions Avoided (tonnes CO _{2e})	12,900	11,000	23,900
Waste Diverted to Landfill (tonnes)	2,600	251,200	253,800
Virgin Materials Displaced (tonnes)	1,500	232,200	233,700
Industrial Water Savings (m ³)	1,000	1,152,000	1,153,000
# Workshop Participants	162	139	301
# Resources Identified	2,302	1,824	4,126
# MWE Resources Identified	950	952	1,902
# Synergies Identified	1,303	1,117	2,420
# Synergies Converted	96	64	160
# Synergies Implemented	16	6	22

Cost-Benefit Analysis

Given that only 160 out of more than 3,500 potential matches have converted to Active Synergies by regional practitioners so far, and even among those 160, we are still awaiting implementation and outcome data, **the benefits from NISP® Canada could be far, far greater**. However, as we have seen, these benefits will likely only accrue if there are sufficient resources to support practitioners, who are key to implementation. It is the nature of business, especially SMEs which make up 95% of businesses in BC, that very few matches proceed to implementation without the assistance of a practitioner.

From a business perspective, these outcomes were achieved only when businesses calculated a positive cost-benefit ratio; no business was required to implement a potential synergy unless it made business sense to do so. From a government perspective, a collective investment of \$1M was made to support the delivery of the pilot. Government funding catalysed direct economic benefit (to-date) to a factor of 6.3:1, a phenomenal return on investment. When carbon pricing of \$30 / tonne CO_{2e} is added to the direct economic benefit, then

government investment in the NISP® Canada pilot provided an economic return of 7 to 1.

The pilot outcomes demonstrate that the NISP® model is feasible in Canada, and that, has been seen internationally, the NISP® model catalyses market-driven action resulting in significant environmental benefits. These results definitively support the continuation and expansion of NISP® Canada in BC and nationally.

Synergy Pipeline: Potential Matches

More than 3,500 potential matches have emerged from the twelve pilot workshops. The majority of potential matches are for materials. Interestingly, the second most common type of match is for expertise. This speaks to the NISP® model's potential to foster knowledge exchange and innovation. An overview of the potential matches to date is shown in Figure 5.

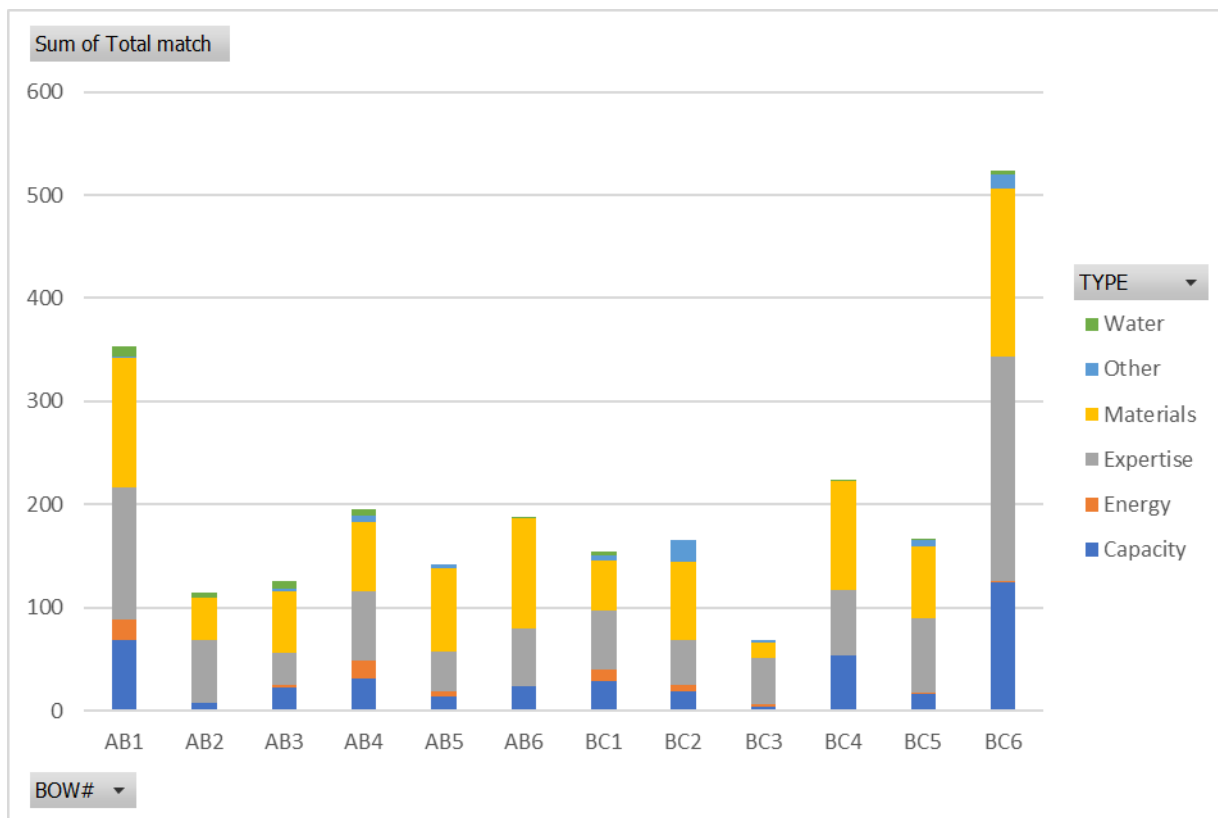


Figure 5: Overview of Potential Matches Per Type, Both Regions

Selected Symbiosis Case Studies⁹

Theatrically Heating Students

Great Northern Way Scene Shop (GNWSS) is one of Metro Vancouver's most significant producers of sets for regional theatre, opera, and film sets. As a result, it has a steady stream of clean wood waste which currently goes to landfill.

As part of its efforts to reduce its carbon footprint and create infrastructure that doubles as training and research opportunities, **BCIT** is constructing a new, wood-fired district heating system and has capacity for additional feedstock.

Practitioners identified a match between GNWSS's wood waste and BCIT's wood waste needs. This synergy is an example of inter-workshop matching. GNWSS attended the first workshop in October 2017, and BCIT the second in January 2018. BCIT staff discussed how they were building a new Burnaby campus district heating system, fired by clean wood. NISP® Canada had toured the GNWSS in November, and observed first-hand the sort of wood waste generated there. Recognizing a good fit, BCIT and GNWSS were connected by the team shortly after the January workshop, and the two parties continue to finalize the details of this synergy. BCIT is revising its boiler selection after the initial EU certified unit it purchased and installed was rejected by Canadian regulators. Once the new boiler is purchased and installed (estimated late 2019), GNWSS wood waste will begin heating students (buildings) at BCIT!

This synergy is highlighted in a [video](#) produced by Metro Vancouver, showcasing NISP® Canada.

⁹ Specific quantitative outcomes are generally not shown as most companies prefer to have their results confidential and included only in our aggregate outcomes.



Papering the Arts

Royal Printers has set its sights on being the most sustainable printer in Canada, and has numerous sustainability initiatives underway, including powering its printers with green power. Their operations do result in 14" wide waste roll ends ('buttends' in printing industry parlance) that are currently sent out for recycling.

Dizz McGruber, an artist residing in New Westminster, is seeking rolls of paper for her projects. Ms McGruber works out of the **100 Braid Street Studios**, which houses 16 artists' studios as well as gallery space. Ms McGruber was referred by Susan Grieg, another artist based at 100 Braid Street Studios. Ms McGruber was pleased to source of buttends from Royal Printers, and may return for more in a few months. In the meantime, NISP® practitioners are also seeking out other artists in the region who might have similar use for the paper, including continually checking in with 100 Braid Street Studios, other artists and arts community representatives who have attended workshops so far.

Put Your Local Beer Down on that Reclaimed Table

Wood Shop Worker's Co-op is a worker-owned co-operative that produces beautiful wood furnishings using only reclaimed and sustainably sourced wood. They are always seeking clean, usable wood waste.

Faculty Brewing reflects its founder's experience as a professor and, just like a university, supports experimentation and innovation and is a "... place of idea-sharing and collaboration." – perfect for industrial symbiosis. As part of their operations, they end up with approximately 16 wooden pallets per month which are currently landfilled.

Faculty Brewing is now sending all its pallets to Wood Shop! In addition, NISP® practitioners are connecting Wood Shop with Paramount Pallets to see if Paramount Pallets might be able to provide clean wood waste to Wood Shop.

Naturally Crafted Pavilion

Unbuilders (Naturally Crafted Ltd.) "...is Canada's foremost deconstruction company. Based in Vancouver, British Columbia, we unbuild homes by hand and salvage almost everything, including irreplaceable old growth lumber, windows, doors, cabinets, fixtures and appliances."

World of Walas is a Dutch-founded, international company with sustainability at its core. From developments that lead the way in applying clean technologies, biobased design, and circular economy principles, to catalysing knowledge exchange via its Dutch Design Centre in Vancouver, World of Walas is a world leader in taking sustainability action.

Both companies participated in NISP workshops, with World of Walas indicating it might be able to use wood waste in its displays and trade show pavilions. A NISP® Canada practitioner met with both parties several times to shepherd the synergy. Fittingly, World of Walas used salvaged wood from Unbuilders to construct the large European innovation Pavilion at the 2019 BC Tech Summit 2019 Vancouver.

Fashion-friendly Tissue

Kruger Products is a Canadian company with 5 papermaking and converting and 3 converting-only plants in its portfolio. Kruger produces facial tissue at its New Westminster plant. They achieved FSC® certification in 2011, the first tissue company in Canada to do so. Kruger produces more than 140 third-party sustainability certified products.

Fabcycle operates firmly in the circular economy, collecting textile waste from apparel production and facilitating its reuse. In addition to online sales, Fabcycle also runs a storefront in Vancouver – the Textile Waste ReUSE Centre, which also functions as a creative space to allow designers and artists to experiment with the scraps. Fabcycle was seeking heavy duty tubes to help organize the textiles in the storefront.

During a site visit to Kruger, a NISP® practitioner noticed cardboard tubes in the waste bin, resources which weren't originally tabled at a workshop. The practitioner was able to broker the transfer of tubes from Kruger to Fabcycle.

Pallets are Paramount in Edmonton

Paramount Pallet is the largest provider of pallets, including recycled pallets, in Canada. A socially responsible firm, they launched the Skids for Kids Foundation in 2009 to work with charitable organizations working with children, including those struggling with illness.

Univar Canada distributes chemicals and ingredients globally, and also provides related value-added services. Their products and services support affordable energy, clean drinking water, reliable food sources, and health. Their Edmonton facility generates used pallets that were being sent to landfill.

Shell Canada's Scotford Complex "...consists of a bitumen upgrader, oil refinery, chemicals plant and a carbon capture and storage (CCS) facility. It is one of North America's most efficient, modern and integrated hydrocarbon processing sites, converting oil sands bitumen into finished, marketable products." These operations also generate a large number of used pallets, which are currently sent to landfill.

The City of Edmonton's Waste Management Centre receives pallets for future landfill disposal, and had a large stock pile. These pallets will now be picked up by Paramount Pallets.

GEEP Canada (Global Electronic Electric Processing) ensures the responsible and safe reuse and recycling of electronic waste and electronic asset disposition. Many of the electronics arrive on heavy pallets, which GEEP must then dispose of.

Goodwill Industries of Alberta is a not-for-profit social enterprise, and is one of the most significant employers of people with disabilities. Managing donations of clothing and household goods, "[G]oodwill Industries of Alberta strives to be a model organization that integrates sustainability practices and a culture of shared responsibility into all areas of operations and services". Goodwill had stockpiled used pallets and was seeking an outlet for them.

Paramount Pallet has collected batches of used pallets from each of the partners listed above. Univar has reported saving \$3,000 in disposal costs while diverting 8 tonnes of wood waste from landfill. Data from Shell indicate that Paramount collected 1,200 pallets, diverting 3 truckloads, or 21 tonnes, or wood waste from landfill. The City of Edmonton estimates this synergy will divert 1,000 tonnes of pallets per year. For GEEP, this synergy utilizes 12 trucks full of pallets – that's 4,800 pallets equaling 142 tonnes of wood. Paramount also collected 1 tonne of used pallets from Goodwill. Paramount was able to clean and repair the 1,172 tonnes of pallets, then sell them for almost \$14,000. The 'have' companies will continue to stockpile pallets for Paramount, which plans to collect more batches in the future. Plus, there are more synergies in the pipeline!

Getting an Energy Boost from (Waste) Coffee

Tim Horton's (Devon) is a franchise operation for the iconic Canadian doughnut and coffee shop. The location generates food waste, including significant quantities of coffee grounds.

EcoGrowth is a clean technology company with reduce, reuse, recycle as a core principle. One of their primary technology developments is a waste-to-energy system that runs on biomass or municipal solid waste.

EcoGrowth has collected 1 tonne of food waste from the Tim Horton's in Devon to test in its biomass technology. If this works, then an EcoGrowth system may be installed at the Tim Horton's to turn waste back into energy (hot water) to use back on site.

Selected Synergies Under Development

GEEP produces a shredded e-waste by-product from their process in recycling and up-cycling surplus and recycled e-waste. Golden Environmental Mat is working to utilize this by-product in their facilities to produce plastic mats for industrial and remote sites.

Gruger Family Fungi produces a compost-like 'old' fungus material. Delta Remediation is testing this waste because it appears as if it could work as an oil absorbent. The potential quantities involved are still confidential, but both parties report that this could result in a significant synergy, not to mention the repurposing of agricultural wastes into a new biobased product.

Algae Aquaculture and Industrial Hemp Tech are both in emerging bioeconomic industries. They realized they have complementary biomass processing needs, and are collaborating to seek technologies while sharing cost and risk.

Urban Granite makes stone counter-tops. While cutting them to size, this process generates stone scrapping calculated in \$3-5 thousand of dollars per month in disposal fees. Devlin Construction is evaluating the stone off-cuts to determine if it can crush and reuse them as base road material.

Newlyweds Foods produces herb and spice blends, among other food industry inputs. Its waste streams include a food-grade waxy residue. Groundstream is testing this residue for use in its biofuel systems or in its biofuel log production as a biobased binding agent.

The Fishing Lake Métis Nation (AB) has recently started its own cannabis grow operations. Micron Waste Technologies (BC) has technology that "...turns organic waste into clean water, with solutions to handle specialized organic waste generated by cannabis cultivators, food producers, food operators, hotels, and more." Micron is working with Fishing Lake to see if it could establish a plant that could take Fishing Lake's cannabis wastes and return clean water to the community.

A major chocolatier generates spent coconut oil, which has the potential to fuel a Renewable Natural Gas facility. With the help of FortisBC, the chocolatier will investigate the use of this, and possibly some of its other biobased wastes, to support the growing demand for RNG in BC.

Canadian Mattress Recycling generates waste leather and zippers from furniture recycling. Our Social Fabric is investigating collecting the leather and zippers to support its efforts to upcycle used textiles into new products.

Blara Organic House produces children's clothing from organic cotton. With a strong sustainability core, the company is investigating also producing clothing from recycled textiles. They are working with Mattress Recycling to see if some of the recycled cotton could be used.

Zenabis produces 500 tonnes per year of cannabis waste that comes from stem, leaves and roots of the cannabis plant. Muddy River Technologies is investigating this material as a feedstock to produce biochar.

Emkao Foods generates several tonnes per year of off-spec or waste (but still food-grade) cocoa powder and chocolate chips. Cartem Donuts is investigating the use of this off-spec product as an ingredient in their donuts. Cartem Donuts is also investigating the use of off-spec blueberry waste from Sidhu Farm as an ingredient for its donuts.

PAC Recycling has collected a sample of waste polyurethane crab floats collected by Ocean Legacy, and sent the sample to their partner in Calgary who is recycling mattress foam and under-layer foam.

Green Circle Salons works with salons to 'green' their operations, but also to recover and transform "...up to 95% of the resources that were once considered waste; materials such as hair, leftover hair color, foils, color tubes, aerosol cans, paper and plastics." A North American program, Green Circle Salons has been working with Virginia Tech to develop a bioplastic incorporating human hair cuttings. Green Circle Salons is in discussions with LUSH Cosmetics to incorporate this new bioplastic into its packaging.

Canadian Pine Pollen generates spent pine husks. Originally, they were matched with LUSH Cosmetics, which wanted to investigate using the spent pine husks in its products. LUSH has since connected Canadian Pine Pollen with a smaller soap manufacturer. LUSH is also exploring sending its clean waste metal drums to Canadian Pine Pollen to use to store materials. Canadian Pine Pollen also generates spruce tip waste (mulch), which Dickie's Ginger is investigating for use as a flavouring in its ginger beers. And, Canadian Pine Pollen is also collaborating with Algabloom Technologies to explore the development of new 'superfood' products.

Nada Grocery is also working with LUSH Cosmetics to see if it can upcycle LUSH's 36 tonnes of off-cuts into new retail products.

NISP® Canada Participation

More than 350 organizations have directly participated in NISP® Canada so far. NISP® Canada continues to lead internationally in the number of referrals to other businesses as well. To date, almost 200 more businesses have been referred to the program; these businesses are logged as program prospects until a practitioner follows up to document resource haves and wants, or the business participates in a workshop. Practitioners follow-up with referrals to inform them of a potential match. When the referred company expresses interest, then practitioners frequently arrange a site visit to provide more information about NISP® and their potential synergy opportunities. Sometimes, the referring company or the potential matching company agrees to follow-up with the company referred. As a result of the high number of referrals occurring at NISP® Canada workshops, ISL modified the workshop HAVE/WANT worksheets and the Synergie® software to better track referrals, as shown in Figure 6.

Referrals		
Referring Company:	Table #	Refer to Company:
Delegate Name:		Contact Name:

Figure 6: New Referrals Tracking on NISP® Workshop WANT Sheet

The median distance travelled by businesses to attend a workshop is 30 km in Metro Vancouver and 35 km in Greater Edmonton. The award for greatest distance travelled by a business to attend a workshop goes to Lower Columbia Initiatives Corporation (613 Km) in Metro Vancouver. The maps below show the distribution of workshop attendees in each region.

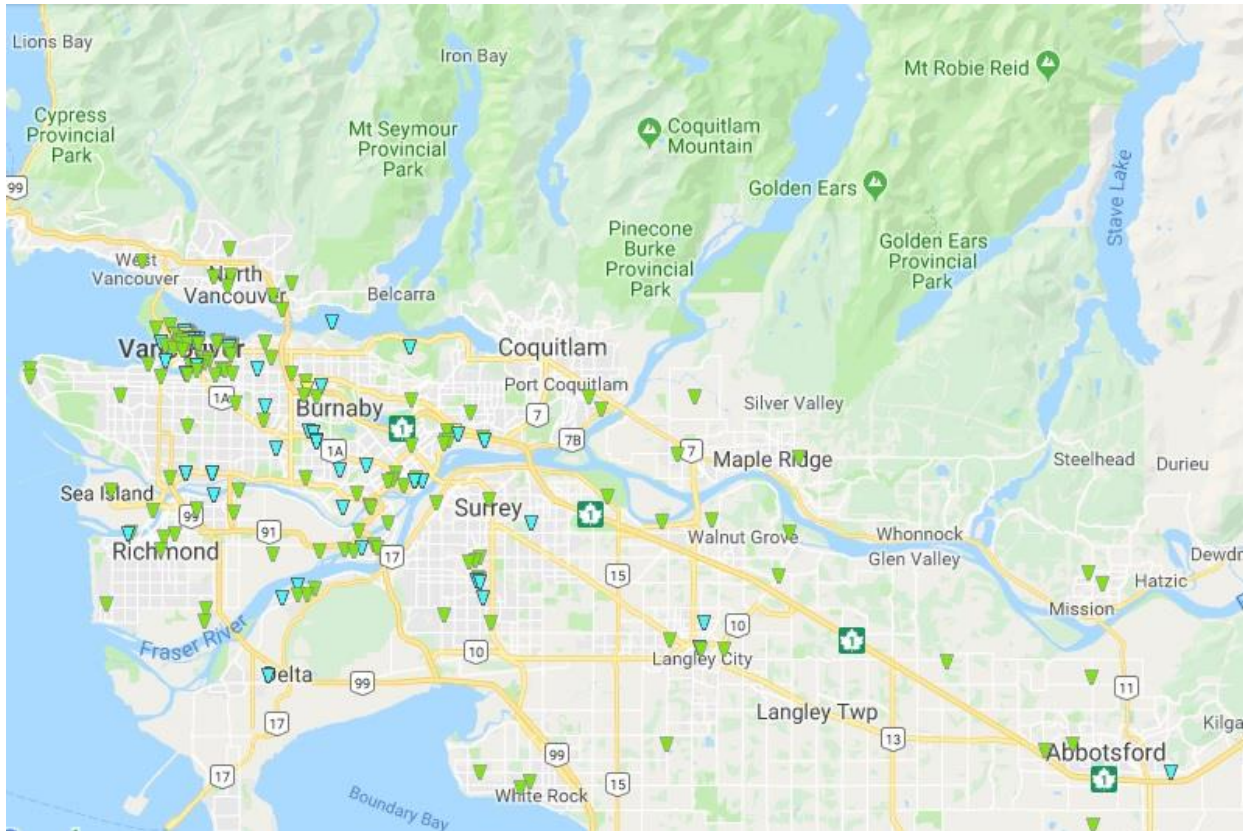


Figure 7: Distribution of Businesses Attending NISP® Workshops: Metro Vancouver

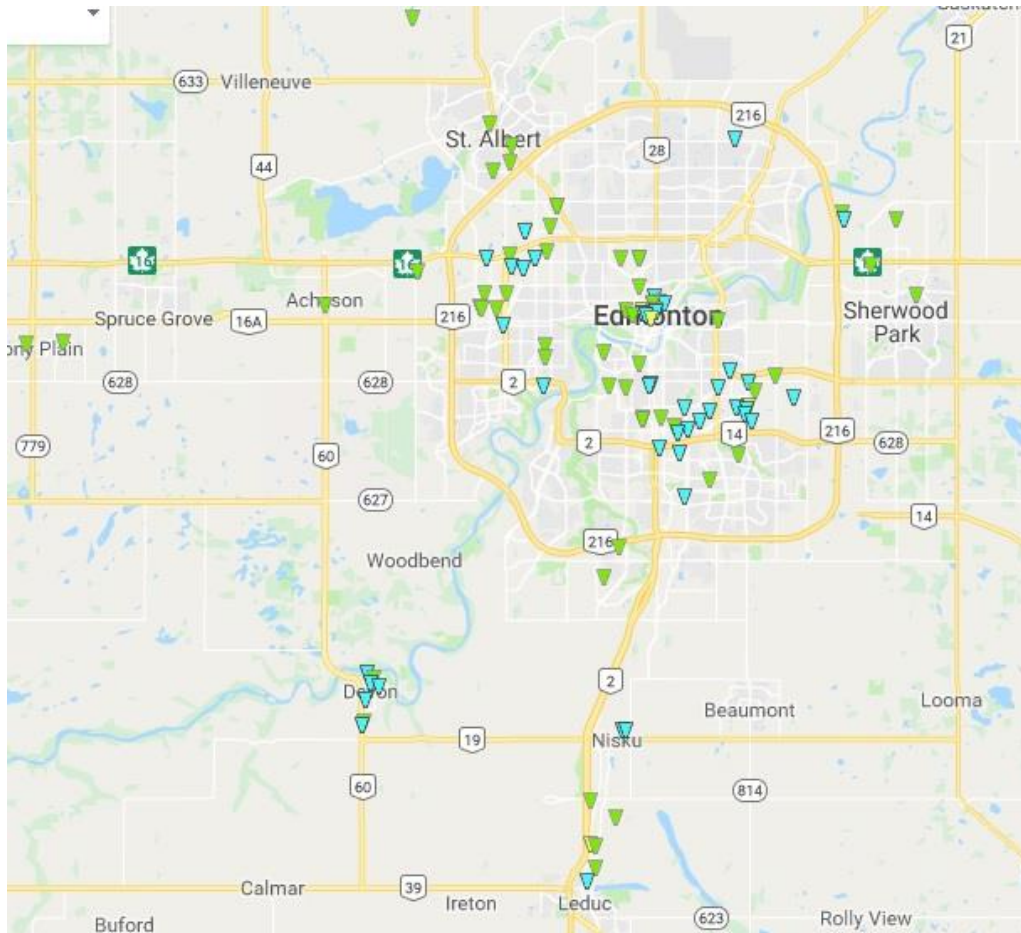


Figure 8: Distribution of Participants Attending NISP® Workshops in Greater Edmonton (excl. Calgary participants)

Biobased Resource Participants

The following businesses have or want resources associated with the bio-economy, such as wood or food wastes. Some businesses are officially within the bio-economy sector, while others represent potential bio-economy synergy partners, potentially supplying or consuming ‘waste’ resources from a bio-economy business.

Biobased Resource Participants – Metro Vancouver

- | | |
|-----------------------------------|------------------------------------|
| 1. 100 Braid St Studios | 6. BC Ministry of Forests |
| 2. ABC Pipe Cleaning Services Ltd | 7. BC Tech for Learning Society |
| 3. AlgaBloom International Ltd | 8. BCIT |
| 4. Associated Labels and Pac | 9. Canadian Mattress Recycling Inc |
| 5. BC Ministry of Agriculture | 10. Canadian Pine Pollen |

11. City of Richmond
12. City of Surrey
13. City of Vancouver
14. Craft Grain
15. Cypress Mountain
16. Douglas College
17. Emkao foods
18. Faculty Brewing Co
19. Fraser River Pile and Dredge Inc
20. FreshEye Thinking
21. FTG2 Solutions Ltd
22. GEEP Canada
23. Great Northern Way Scene Shop
24. Happy Stan's Recycling Services
25. Harvest Fraser Richmond Organics
26. Kruger
27. Lehigh Cement
28. Liberty Contract Management Inc
29. Lucent Biosciences
30. Lush Cosmetics
31. Mattress Recycling
32. MEC
33. Metro Vancouver
34. Micron Waste Technologies
35. Ministry of Energy
36. Naturally Crafted Contracting
37. Net Zero Waste
38. NORAM Engineering
39. Parkland Refinery
40. PCS Technologies
41. Product Care Association
42. Royal Printers
43. Sea to Sky Soils
44. Seen Signs
45. Squamish & District Forestry Association
46. Stella Jones Inc.
47. TetraTech Canada Inc
48. Trans Continental Textile recycling
49. UBC University of British Columbia
50. UnBuilders DeConstruction
51. Urban Impact
52. Vancity
53. Vancouver Airport Authority
54. Vancouver Fraser Port Authority
55. Voltberg Controls
56. Westcoast Cylinders
57. Weyerhaeuser

Biobased Resource Participants – Greater Edmonton

1. AbleIT Inc.
2. Alberta Agriculture and Forestry
3. Alberta Economic Development & Trade
4. Alberta Food Processors Association
5. Alfa Laval Inc
6. Algae Aquaculture Inc
7. Allan R. Nelson Engineering
8. ATCO
9. AWE Solutions Inc.
10. Beaver Municipal Solutions
11. Bionera
12. Canadian Wood Waste Recycling
13. City of Edmonton
14. Delta Remediation Inc
15. Devon and District
16. Eco Smart Energy Solutions
17. Eco-Growth Environmental
18. Elevate Organics
19. Enerkem Alberta Biofuels
20. Essential Hospitality Solutions Inc.
21. First Nations TSAG
22. Fishing Lake Metis Nation
23. GEEP
24. Golden Environmental Mat Services Inc
25. Goodwill Industries
26. Gowan Agro
27. Growing Greener Innovation
28. Homestead Firewood
29. Invigor Bioenergy Corporation
30. IRSI
31. KBL Environmental Ltd.
32. Lehigh Hanson Canada Region
33. Natural Fibre Tech
34. NewlyWeds Foods
35. NorLand Limited
36. Paramount Pallet
37. R&D Green Tech
38. Richmond Steel
39. Saddle Lake Cree Nation
40. Shell Canada Scotford Complex
41. Smart Firewood Products Ltd
42. Sterling Lifestyle
43. Town of Bruderheim
44. Tricon Services Ltd
45. Univar Canada
46. Waste Connections of Canada Inc

Manufacturing Participants

Manufacturers are identified as those with *primary* NAICS codes beginning with 31, 32, or 33.

Manufacturing Participants – Metro Vancouver

- | | |
|-------------------------------------|---|
| 1. AlgaBloom International | 16. Parkland Refinery |
| 2. Blara Organic House | 17. Purdy's Chocolatier |
| 3. Canadian Pine Pollen | 18. Plascon Plastics Corp |
| 4. Cargill EWOS | 19. Royal Printers |
| 5. Emkao foods | 20. Seen Signs |
| 6. Faculty Brewing Co | 21. Seven Leagues |
| 7. Craft Grain | 22. Stella Jones Inc |
| 8. Harvest Fraser Richmond Organics | 23. Superior Tray Systems Inc |
| 9. Hive City | 24. Trans Continental Textile recycling |
| 10. KenDor Textiles Limited | 25. Univar |
| 11. Kruger | 26. Voltberg Controls |
| 12. Lehigh Cement | 27. Weyerhaeuser |
| 13. Lucent Biosciences | 28. Woodshop Coop |
| 14. Lush Cosmetics | 29. Zenabis |
| 15. MEC | |

Manufacturing Participants – Greater Edmonton

- | | |
|--|------------------------------------|
| 1. Advantage Mobile Recycling | 11. Lehigh Hanson Canada Region |
| 2. Alco Industrial Fabricators | 12. Mainstreet Mud |
| 3. Alco Oil Tool | 13. Paramount Pallet |
| 4. Alltec Manufacturing Inc | 14. Rig Hand Craft Distillery Inc |
| 5. DLC | 15. Shell Canada Scotford Complex |
| 6. Edge Equipment | 16. Smart Firewood Products Ltd |
| 7. Golden Environmental Mat Services Inc | 17. Victory Spring Ltd |
| 8. Groundstream | 18. Western Wood Truss Association |
| 9. Homestead Firewood | 19. Willowglen Systems Inc |
| 10. Inkubate Packaging | |

Textile Resources Participants

The following companies had or wanted textile wastes.

Textile Resources Participants: Metro Vancouver

- | | |
|--|-----------------------------------|
| 1. 100 Braid St Studios | 7. Douglas College |
| 2. Big Brothers Clothing Donation Center | 8. EFW |
| 3. Blara Organic House | 9. Fabcycle |
| 4. Canadian Mattress Recycling Inc | 10. Geocycle Canada |
| 5. City of Richmond Environmental Programs | 11. Great Northern Way Scene Shop |
| 6. City of Surrey | 12. KenDor Textiles Limited |

13. Mattress Recycling
14. MEC
15. NORAM Engineering
16. PAC recycling
17. Revivify Recycling Solutions Inc
18. Seen Signs
19. TetraTech Canada Inc
20. The Leverage Lab
21. Trans Continental Textile recycling
22. Univar
23. Upcycle the Gyres Society
24. Urban Impact
25. Vancity
26. Weyerhaeuser

Textile Resources Participants: Greater Edmonton

1. Alberta Agriculture and Forestry
2. Alberta Economic Development & Trade
3. Alberta Innovates
4. AWE Solutions Inc.
5. Beaver Municipal Solutions
6. First Nations TSAG
7. Fishing Lake Métis Settlement
8. Phoenix Industrial
9. Supply Chain Management Association Alberta
10. Tricon Services Ltd
11. Delta Remediation Inc
12. Sleep Country Calgary
13. NewlyWeds Foods
14. Goodwill Industries
15. Gowan Agro Canada

Types of Resources Identified

The types of resources identified are somewhat related to the types of businesses participating. For example, a metal finisher will have scrap metal wastes. But one of the key reasons for NISP®'s success has been its ability to tease out all non-product outputs and secondary inputs for potential Synergie® matches. The same metal finisher might have a significant waste cardboard stream or be interested in a sort-of-clean water stream, for example.

The types and amounts of material resources identified so far are summarized in the following chart. As can be seen in Figure 9 on the following page, wood and food & agriculture resource types were by far the most plentiful type of material resource identified.

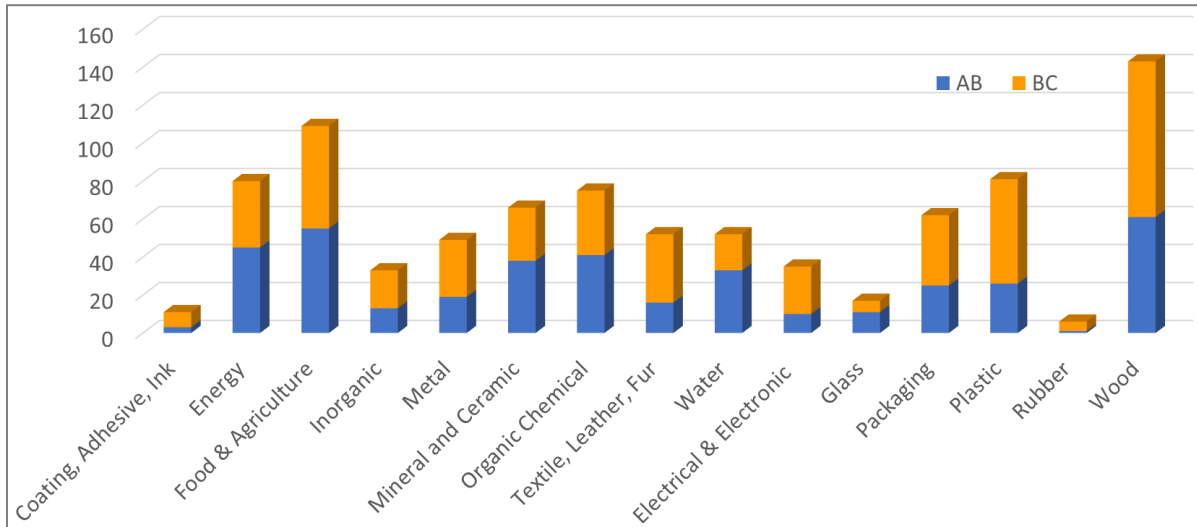


Figure 9: Number of Businesses Having / Wanting Material, Energy, Water Resources Identified, by Category

As has been seen internationally, the NISP® process is also helping to draw out other business symbiosis opportunities related to non-material / non-energy resources such as physical assets and expertise. This is also borne out by the NISP® Canada results to date. The table below summarizes other resources put forward by businesses. This highlights the opportunity for NISP® Canada to support knowledge exchange among businesses; catalyze innovation by connecting new technology providers with potential early adopters / pilot sites; and to better integrate the service and resource / manufacturing sectors. Expertise and capacity top the resources in each region. This belies the myth that businesses do not want to share their knowledge.

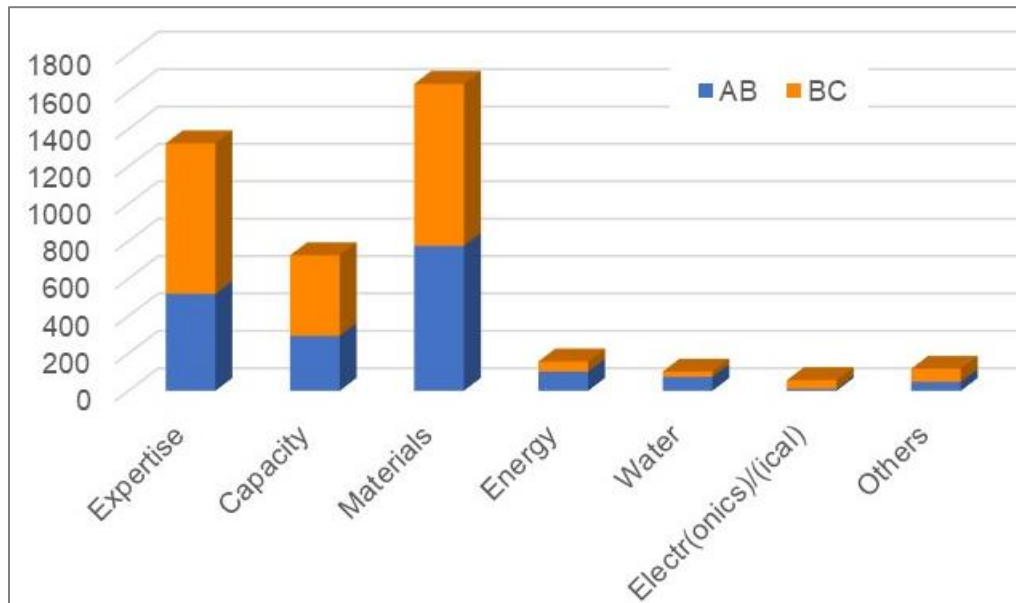


Figure 10: Breakdown of Number of Businesses Having / Wanting Overall Resource Types

Practitioners are working with businesses to better quantify the amounts of resources available.

A *sample* of some of the known quantity items is provided below:

- River dredging – 1,000,000 tonnes/y
- Used smoke and CO detectors – 1,000,000 tonnes/y
- Boiler Ash – 5,000 tonnes/y
- Shredded plastics from mattress recycling – 50,000 tonnes/y
- Used mattresses – 8,000/y
- Printed circuit boards – 10,000
- Food processing effluent – 10,000,000 m³/y
- Plastic supersacks, 1 cubic metre size – 2,600/y
- Cardboard drums – 1,400 /y
- Partially calcined material (dust) - 40,000 tonnes/y

A *sample* of other resources put forward by regional businesses includes:

- Distillery mash;
- Hemp and cannabis growing and processing by-products;
- Pallets and more pallets;
- Waste absorbents;
- Multiple types of wood waste;
- Multiple types of construction waste;
- Multiple types of plastic waste;
- Spent activated carbon;
- Crude glycerine;
- Granite bricks;
- Hydroponic growth agents;
- Various manures; and
- Potato clippings

Knowledge Gained: Adapting the NISP® Model to Canada:

Managing No Shows

Practitioners noticed a relatively high number of no-shows at the workshops. While some absences could be explained by poor weather (a particularly Canadian barrier, especially in the Edmonton area), many could not. Staff from ISL UK were surprised by the number of no shows, which were not as evident in other countries. Practitioners follow up with each no show to determine their reasons for non-attendance. Reasons given vary from illness, to a sudden urgent work issue, to simply forgetting!

NISP® Canada Adaptation: We have instituted a nominal \$15 fee to discourage no shows. Practitioners also follow-up with no shows, offering to collect resource information in person so that they can search for potential matches for the business. Some businesses have agreed, while others have simply elected to register for the next workshop.

Recruiting Manufacturing Participants

Internationally, NISP® has demonstrated benefits to businesses of all sectors and sizes. Nonetheless, manufacturing frequently forms a core in other programs, forming between 35% and 55% of program participants. Currently, manufacturing accounts for around 21% (42/197) of the program's Metro Vancouver participants and 15% (26/178) in Greater Edmonton. While manufacturing facilities are the primary consumers of resources and major waste generators oftentimes, they proved challenging to recruit to the program (see the Productivity Paradox). What has been thought-provoking, though, is the type of manufacturing participants so far. As with most OECD countries, Canada has faced a decline in manufacturing jobs in recent decades. However, we are seeing participation from manufacturing facilities in sectors that barely existed even a decade or two ago, such as micro-breweries / micro-distilleries; clothing manufacturers sources scrap textiles; algae-based aquaculture; and value-added cannabis operations. Furthermore, the historic line between a 'manufacturer' and another type of business becomes blurred in the modern economy. For example, a waste to energy plant could be considered as a manufacturer from a resource flow standpoint, but such facilities are not captured in data for 'manufacturers'. Lastly, it's important to note that the participation of manufacturers was not tied to larger results; outcomes were higher in Greater Edmonton, even though official manufacturing participation was lower.

NISP® Canada Adaptation: We established a partnership with BC Alliance for Manufacturing, an umbrella organization for manufacturing industry associations. NISP® Canada is now featured prominently on their home page <https://www.manufacturingbc.org/>, and a feature article on NISP® Canada was included in a 2018 BCAM journal. The Alliance has helped to promote NISP® workshops to its members, including direct emails. In addition, we completed strategic

on-on-one follow-up to engage manufacturers, using media as a lever, such as when a manufacturer was profiled in a local newspaper. Manufacturing participation increased dramatically in the last workshop, bringing the overall manufacturing participation from 12% as of December 2018 to 20% by March 2019. We also established a partnership with the AB Council of Technologies, which promoted NISP® Canada workshops and even hosted NISP® as part of its Western Canada Hemp Industry conference. We will continue to target emerging manufacturing sectors, which, while frequently comprising small and very busy businesses, are also keen to embrace sustainability and innovation. In future, we would like to work to adapt the SYNERGie® tool to capture non-traditional manufacturing, such as bioenergy facilities, in manufacturing counts.

Barriers to Active Synergy Implementation

After synergy opportunities, are identified (primarily via workshop matches, but also due to practitioner site visits and SYNERGie® analysis), practitioners follow-up with businesses to support implementation. Sometimes, as businesses and practitioners examine an opportunity more deeply, they identify a barrier that cannot be readily overcome at this time. As shown in Figure 11, the barriers so far are diverse and sometimes ‘quirky’, as demonstrated by the fact the largest category of barriers is ‘Other’. The next most significant barriers are ‘Technical’ and ‘Financial’, which are discussed in more detail below

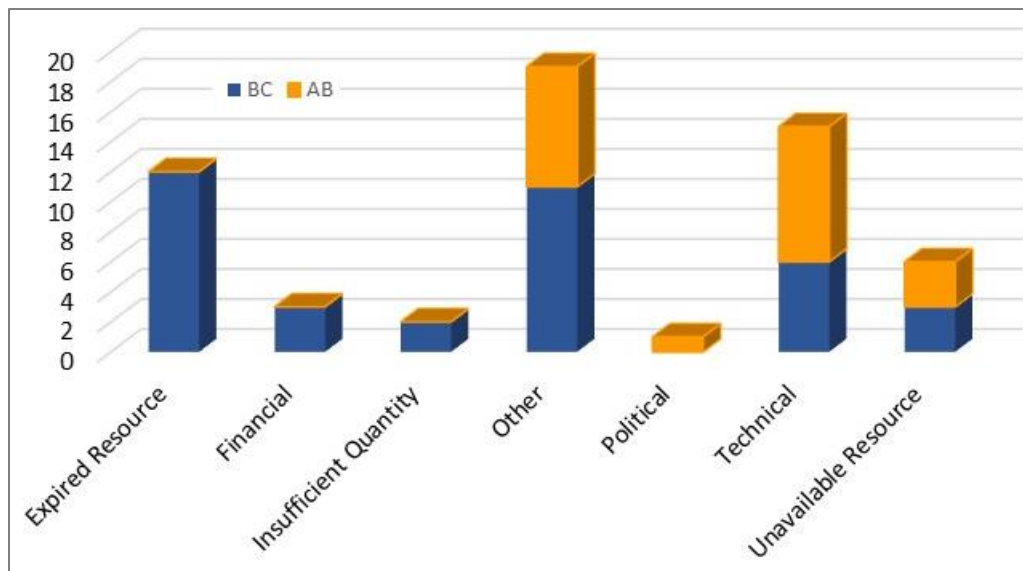


Figure 11: Barriers to Active Synergy Implementation, By Type (BC+AB)

Technical barriers include any challenges with resource quantity or quality; transportation; or corporate practices such as procurement policies.

Financial barriers are straightforward – the company that has the resource needs or expects a certain price for its resource that the wanting company cannot justify or transportation costs are too much. Sometimes, financial barriers are intertwined with technical barriers, such as when the costs to sort or remove contamination from a resource based on currently available technology are too high.

Only one potential match advanced to a synergy Idea stage but has not yet been implemented due to a political (regulatory) barrier. This barrier was cited for a new algae-based aquaculture facility with a potential match with a new hemp facility constructed in response to Canada's recent legalization of cannabis. With both parties in new industries, there is some regulatory uncertainty regarding the sale and transfer of cannabis industry wastes as well as regarding environmental regulations affecting the aquaculture facility. Practitioners continue to monitor this particular synergy, and remain ready to help it progress.

Challenges categorized as 'other' include companies reporting that they are interested in pursuing their matches, but too busy at the moment, with several that are moving or upgrading location. Sometimes, equipment or operational changes render a resource unusable or no longer required, or just delay implementation. Occasionally, there were multiple potential matches for a single resource, and the fastest acting firms secured the resource, blocking implementation of the remaining matches.

One other barrier over which the practitioners have little control is the sudden closing of a potential synergy partner. For example, in Metro Vancouver, Harvest Power's Richmond location looked to be a site that could use organic wastes of various types that had been identified by a number of participants. However, due to ongoing challenges related to odour control, the location in question was forced to cease operating, removing from the region a significant potential destination for organic wastes. The principal of Bogoecco, a small, specialty environmental technology company, suddenly passed away. As he was the sole proprietor of this firm, all the potential synergies associated with Bogoecco are no longer viable.

NISP® Canada Adaptation: With respect to financial and technical barriers, practitioners research and make referrals to appropriate clean technology funding and research and development support e.g., Innovate BC. With respect to technical barriers, additional resources for future phases of NISP® Canada would be helpful to support collaborative engagement of participants together around specific resources with multiple HAVE or WANT parties, along with researchers and relevant investors, to try to address common / similar financial barriers. Based on the pilot outcomes, businesses have not flagged regulatory or policy changes necessary to advance industrial symbiosis.

The Canadian Productivity Paradox

While businesses participating in NISP® workshops are engaged, with some even returning to a second or third workshop, and Canadian businesses apparently lead the world in providing helpful referrals, securing businesses' attention to advance implementation has been extra challenging. Businesses are keen but extremely busy. While most businesses reply encouragingly to post-workshop follow-up emails and phone calls, practitioners have often found it difficult to schedule subsequent meetings with the businesses. Often, very long lead times are required before a suitable meeting time can be found, particularly if more than one participant is involved. Relatively few businesses report having contacted their potential synergy match on their own, illustrating the need for continued practitioner follow-up.

Other international NISP® programs have certainly reported that many businesses, especially small ones, do not have the resources to implement their synergies, although this seems especially prevalent in Canada. According to Statistics Canada, almost all Canadian firms are small businesses (< 500 employees), with micro-enterprises (1 to 4 employees) making up 54.1% of all private employers, while 86.2% of all private employers in Canada employ less than 20 people.

Much analysis and literature around this subject starts from the premise that companies are rational actors. This is not necessarily the case. Certainly, International Synergies has experienced being able to put forward excellent business cases for synergies with potentially high rates of return and have then found for whatever reason (not wanting to change, perceived too much effort, timing not quite right, politically difficult to gain internal consensus, etc.) that companies are unwilling to progress.

Fundamentally, SMEs and micros typically do not have the time or priority to allocate to these types of searches. Program managers on the SME agenda find that SMEs are lacking institutional support to take advantage of the economic opportunities in resource efficiency, and encounter significant barriers to entry. **Ultimately, NISP® Canada delivery will need to respond to Canada's high SME make-up by including more practitioner site visits and allowing more time between workshops.** Other international regions have reduced the number of regional workshops per year to 2 or 3 instead of 4 (quarterly). Based on the amount of time required to execute workshops, we believe that delivering 4 workshops per year per region is limiting practitioner time for follow-up with businesses to advance synergies.

NISP® Canada Adaptation: Practitioners have focused their follow-up efforts, not just checking in with partners in a potential synergy, but actively setting meetings for both parties to come together. Direct calendar invites are used regularly, rather than email queries. In future, we would like to explore the use of multi-stakeholder *implementation* meetings to bring together parties working on similar synergies - e.g., biomass to RNG potential - with related support organizations such as regulators or innovation funders. This will require additional financial resources.

NISP® Canada Adaptation: We were committed to delivering 6 workshops in Metro Vancouver and Greater Edmonton regions. As we scope new regions and/or extension of NISP® in these regions, we will reduce the number of workshops unless there are sufficient resources to retain more practitioners.

What is a NISP® ‘Region’?

One of the questions in adapting the NISP® model to Canada was defining the size and location of ‘regions’. The original UK-program was delivered across 13 regions, while covering Turkey requires 26 regions.

Although several participants drove hundreds of kilometres to participate in the program, the median distance travelled within Metro Vancouver was 30 km and within Greater Edmonton was 35 km. The participants who drove the furthest were from rural areas; we don’t believe participants would make the reverse commute from an urban location to a rural workshop. This does speak to the fact, though, that rural regions could be larger geographically than urban ones.

There is also a limitation with respect to practitioner efficiency. The more time a practitioner spends ‘on the road’, the less time s/he can spend actively working with businesses.

NISP® Canada Adaptation: There are likely to be programs centred around metropolitan centres, roughly radiating out 50 to 75 km from the centre. While some regions might in practicality overlap (e.g., a business in Langley might attend a workshop in Surrey or Chilliwack), personal driving distance will determine the size of most regions. The pilot did not specifically cover rural areas. However, based on our discussions with businesses and local government from rural areas, rural program regions will be larger and must be resourced for greater practitioner travel as well as more practitioner site visits to businesses for whom a workshop in a regional centre might not be convenient. Lastly, the international NISP® model is actually adapting SYNERGie™ in 2019 to accommodate rural businesses by boosting its capacity for businesses to enter their resources directly via a web-based interface. We will be adaptively managing rural delivery as part of our efforts in the new NISP® Canada Western Kootenay region.

Businesses Think Regionally

As the maps in Figure 7 and Figure 8 show, a local government boundary is no barrier to business participation in a workshop held within another local government jurisdiction. Driving distance (and commuting obstacles such as bridges that bottleneck in rush hour) affected businesses’ decisions to participate. No business indicated it only wanted to explore opportunities with businesses located in the same city. Although ‘industrial’ businesses are often

not near major transit lines, it was also counter-intuitively reported in Metro Vancouver that many participants preferred a location near a rapid transit station.

NISP® Canada Adaptation: We will continue to move workshops around regions; they do not need to be in the main city / town to attract participants. We will also continue to emphasise to local governments that a regional approach is the best for achieving industrial symbiosis and advancing a circular economy.

Grant-Based Funding: Essential, But Unsustainable

The NISP® Canada pilot relied on funding from eight agencies and three levels of government. At this time, it appears that grant-funding, especially from government, will be the main short-term funding model. The NISP® pilot was run on a **cost-recovery basis** by the not-for-profit Light House Sustainable Building Centre. Based on international outcomes, it appears that the NISP® model lends itself well to alternative financing such as green bonds or a trust funded by businesses' financial savings. However, until NISP® Canada outcomes were determined, it was difficult to have a concrete discussion regarding this option in Canada.

NISP® Canada Adaptation: Given the challenges securing funding to run the pilot on a cost-recovery basis, it is absolutely not feasible for this to be delivered as a consulting model, which would require approximately 3x the financial resources. We foresee grant-funding as critical to extend the program in Metro Vancouver and Greater Edmonton, and to expand to new regions, for at least the next 2 years. However, **it is crucial that government agencies consider that not all low carbon, circular economy solutions involve capital projects; it is difficult for NISP® Canada to fit in such funding programs, despite its ability to deliver on stated policy objectives.** Lastly, with interest in the circular economy exploding nationally and internationally, we believe there will soon be critical mass to collaborate internationally to develop alternative funding models for industrial symbiosis and related circular economy initiatives. Such solutions will be necessary, securing funding for NISP® and similar initiatives beyond 3-5 years is a global challenge.

Conclusion

The NISP® Canada pilot was a success. NISP® Canada should continue, as it catalyses profitable private sector circular, low carbon economy activity with no new regulations required.

The NISP® Canada pilot engaged more than 350+ businesses in only 18 months, starting ‘from scratch’ in terms of regional business awareness of the model and pilot. To date, even if no other potential matches are converted to active synergies and if no other data is collected from activated synergies, the NISP® Canada pilot will result in:

- ✓ \$6.3M in direct economic impact to participating businesses;
- ✓ 23,800 tonnes of CO_{2e} emissions avoided, **equivalent to more than 5,000 passenger vehicles driven for one year¹⁰**; and
- ✓ 253,800 tonnes of waste diverted from landfill

The pilot demonstrated the **importance of facilitated industrial symbiosis**; Canadian businesses are largely SMEs, and they do not have the resources to shepherd their opportunities to completion. As discussed in the feasibility study that preceded the pilot, more passive materials exchanges, while being relatively low cost, simply do not result in the same level of implementation and engagement. The NISP® Canada practitioners were a crucial element of success, working directly with businesses to help them evaluate and implement their opportunities.

Based on the pilot success, NISP® Canada is already growing: We have already launched in the **BC Lower Columbia**, in collaboration with the Lower Columbia Initiatives Corporation and Metal Tech Alley. We have a commitment of support to continue the **Metro Vancouver** program from the Vancouver Economic Commission (VEC), which is hosting the next regional workshop late September. We also have financial support from the City of **Edmonton**, which is supporting NISP® Canada in securing regional funding from other local governments, and in-kind support from Edmonton International Airport (YEG), which has offered to host the next regional workshop. Grant applications are moving through City of **Calgary**. We are also working to build a **South Vancouver Island** program such that its first workshop could coincide with the Coast Waste Management Association’s AGM in October, and are also building a program for **Mid- and North Vancouver Island**. The number of other jurisdictions that have expressed interest grows monthly.

The NISP® Canada pilot has positioned BC and Alberta as circular economy leaders; its achievements earned it invitations to Environment Canada & Climate Change’s invitation-only Circular Economy Expert Roundtable in March 2019 and to the invitation only United Nations Environment Program Great Lakes Circular Economy Forum in June 2019. NISP® Canada was

¹⁰ U.S. EPA Greenhouse Gas Equivalencies Calculator <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

also represented at the World Circular Economy Forum in Helsinki in June 2019, including being highlighted at a special industrial symbiosis side session. In future, NISP® Canada will be delivering a presentation and a workshop at EcoCities in Vancouver October 2019, and is engaged with the organizing committee of the World Circular Economy Forum 2020, to be held in Canada.

NISP® Canada now stands as an exemplary demonstration of regional, provincial, and national action on the low carbon, circular economy agenda.

Governments at every level should continue to support NISP® Canada's valuable contribution to Canadian efforts to tackle our global climate and ecological crises.

APPENDIX A WORKSHOP SUMMARY REPORTS

APPENDIX B: GREENHOUSE GAS EMISSION SAVINGS CALCULATION METHODOLOGY

Washington Industrial Waste Coordination (Industrial Symbiosis)

Program Recommendations

Appendix D: EU Industrial Symbiosis Program Pre- Standard

NOVEMBER 2019

LIGHT HOUSE SOCIETY

**with International Synergies Ltd.
and Center for Sustainable
Infrastructure**

PREPARED FOR

**Washington State
Department of Commerce**



CEN

CWA 17354

WORKSHOP

December 2018

AGREEMENT

ICS 13.020.20

English version

Industrial Symbiosis: Core Elements and Implementation Approaches

This CEN Workshop Agreement has been drafted and approved by a Workshop of representatives of interested parties, the constitution of which is indicated in the foreword of this Workshop Agreement.

The formal process followed by the Workshop in the development of this Workshop Agreement has been endorsed by the National Members of CEN but neither the National Members of CEN nor the CEN-CENELEC Management Centre can be held accountable for the technical content of this CEN Workshop Agreement or possible conflicts with standards or legislation.

This CEN Workshop Agreement can in no way be held as being an official standard developed by CEN and its Members.

This CEN Workshop Agreement is publicly available as a reference document from the CEN Members National Standard Bodies.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

© 2018 CEN All rights of exploitation in any form and by any means reserved worldwide for CEN national Members.

Ref. No.:CWA 17354:2018 E

Contents		Page
European foreword		3
Overview		5
1	Scope	7
2	Normative references	7
3	Terms, definitions and abbreviation	9
3.1	Terms and definitions	9
3.2	Abbreviations	12
4	Core Elements of Industrial Symbiosis	13
5	Drivers for Industrial Symbiosis	13
6	Approaches to Industrial Symbiosis NOTE	15
7	Industrial Symbiosis Implementation: Good Practice	18
7.1	Factors Enabling Good Practice	18
7.2	Actions Representing Good Practice	19
Bibliography		20

European foreword

This Workshop has been proposed by 4 European projects working to advance the uptake of industrial symbiosis across Europe and globally. Contribution to standardization activities has been specified as one of the means for dissemination for the projects SHAREBOX (Secure Platform for the Flexible Management of Shared Process Resources) and EPOS (Enhanced energy and resource efficiency and Performance in process industry Operations via onsite and cross-sectorial Symbiosis) of the European Commission's Horizon 2020 programme, SPIRE Sustainable Process Industries PPP. Advancing policy to stimulate industrial symbiosis is an objective of Interreg Europe projects TRIS (Transition Regions towards Industrial Symbiosis) and SYMBI (Industrial Symbiosis for a Resource Efficient Economy).

CWA Industrial Symbiosis was developed in accordance with CEN-CENELEC Guide 29 "CEN/CENELEC Workshop Agreements – The way to rapid agreement" and with the relevant provisions of CEN/CENELEC Internal Regulations – Part 2. It was agreed on 2018-10-22 in a Workshop by representatives of interested parties, approved and supported by CEN following a public call for participation made on 2018-01-24. It does not necessarily reflect the views of all stakeholders that might have an interest in its subject matter.

The final text of CWA Industrial Symbiosis was submitted to CEN for publication on 2018-11-12. It was developed and approved by:

International Synergies Limited
 INEOS Group AG
 University of Ghent
 CEPI - Confederation of European Paper Industries
 CEMBUREAU - the European Cement association
 Motiva
 University of Sussex
 EIT RawMaterials
 University of Cantabria
 Ministry of Development, Turkey
 Industrial Symbiosis Limited
 ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development
 Gorenje Surovina
 BTC Company
 Evonik Industries
 DECHEMA - Expert network for chemical engineering and biotechnology
 BSI Group
 ACCIONA Construcción
 UNE
 AIDIMME - Technological Institute
 Dr. Teresa Domenech, consultant
 Giovanni Impoco, consultant

It is possible that some elements of the CWA Industrial Symbiosis may be subject to patent rights. The CEN-CENELEC policy on patent rights is set out in CEN-CENELEC Guide 8 "Guidelines for Implementation of the Common IPR Policy on Patents (and other statutory intellectual property rights based on inventions)". CEN shall not be held responsible for identifying any or all such patent rights.

CWA 17354 (E)

The Workshop participants have made every effort to ensure the reliability and accuracy of the technical and non-technical content of the CWA Industrial Symbiosis, but this does not guarantee, either explicitly or implicitly, its correctness. Users of the CWA Industrial Symbiosis should be aware that neither the Workshop participants, nor CEN can be held liable for damages or losses of any kind whatsoever which may arise from its application. Users of CWA Industrial Symbiosis do so on their own responsibility and at their own risk.

Overview

The 2018 Amendment to the Waste Framework Directive (2008/98/EC) passed into law calls for member states to promote sustainable use of resources and industrial symbiosis. As industrial symbiosis is further integrated into the policies, reports and recommendations of the European Commission across multiple DGs and various member states at the national, regional and local scale, the variety of terminologies used in these documents can be confusing and sometimes misleading to those wishing to implement industrial symbiosis. Such confusion dilutes the effectiveness of the approach to deliver resource efficiency, greenhouse gas reduction and economic benefits.

Resource efficiency through industrial symbiosis offers economic opportunities for European industry. This CEN Workshop Agreement (CWA) is intended to help organisations, governments and individuals consider and implement industrial symbiosis. To support the effective adoption of industrial symbiosis by the public and private sector and to advance toward mainstream adoption, this CWA provides a consensus on the core elements of industrial symbiosis to enable its identification and on good practice approaches to industrial symbiosis implementation across Europe and beyond. These common elements and approaches can form the basis for policy, recommendations and widespread implementation.

Specifically, this CWA sets out the following:

1. Core elements of industrial symbiosis;
2. Drivers for industrial symbiosis;
3. Approaches to industrial symbiosis;
4. Industrial symbiosis implementation: good practice.

Industrial symbiosis is the use by one company or sector of underutilised resources broadly defined (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials) from another, with the result of keeping resources in productive use for longer. Core elements of industrial symbiosis are the aspects that enable its identification. Elements considered core to industrial symbiosis are:

- Returning underutilised resources (often called waste) to productive use;
- Information about opportunities (e.g., data on other organisations' resources, or new technologies) is required to be able to advance a synergy;
- Business conditions incentivising industrial symbiosis, which may be through market conditions or through policies and regulations; and

Four common approaches to industrial symbiosis (that are not mutually exclusive) vary depending on where the onus for identifying and advancing opportunities lies:

1. Self-organised: a bottom-up approach resulting from direct interaction among industrial actors, without external coordination. Expertise resides within the organisations with resources and opportunities; organisations identify, assess and advance opportunities themselves.
2. Facilitated: wherein a third-party intermediary coordinates the activity, working with organisations to identify opportunities and help bring them to fruition. Facilitators (sometimes referred to as practitioners) work with the companies to identify, assess and advance opportunities; often the onus is on the facilitators to progress opportunities. Facilitator business models vary from commercial brokers to public investment networks and any combination thereof.
3. ICT-supported: industrial symbiosis activity is supported by an ICT system to capture and manage data on resource availability and potential synergies. The onus lies with the software users, be they companies, other organisations or facilitators.

CWA 17354 (E)

4. Strategic or planned: a top-down approach where networks are formed following a central plan or vision that includes attracting new businesses to regeneration sites or purpose-built developments. The onus lies with the central body (often public sector) implementing the plan or vision.

Good practice implementation in any approach requires the following steps:

1. Fully characterising the resources available: thinking broadly about resources (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials); and reassessing waste for value as a resource.
2. Identifying and assessing opportunities to return underutilised resources to productive use: statistically, most (not all) reuse opportunities are outside one's own sector, so cross-sector knowledge may be required.

Matching the available resource with the appropriate opportunity, addressing technical, economic, and legal requirements. Intermediate transformation steps may also be required.

1 Scope

Industrial symbiosis is the use by one company or sector of underutilised resources broadly defined (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials) from another, with the result of keeping resources in productive use for longer. It presents a systems approach to a more sustainable and integrated industrial economy that identifies business opportunities to improve resource utilisation and productivity. The objectives of this CEN Workshop Agreement (CWA) are to support the mainstream adoption of good practice approaches proven through implementation by advancing the mutual understanding of actors (public, private, third sector, and community) currently using the term industrial symbiosis in different ways. This CWA is intended to help the above actors consider and implement industrial symbiosis.

2 Normative references

The following **standards-related references** are central to this document:

- BS 8001: 2017 “Guidelines to a Circular Economy” and references therein
<https://www.bsigroup.com/en-GB/standards/benefits-of-using-standards/becoming-more-sustainable-with-standards/BS8001-Circular-Economy/>
- IWA 27: 2017 “Guiding principle and framework for the sharing economy”
<https://www.iso.org/standard/72643.html>

The following **related references (reports, policies)** are central to this document:

There are multiple directives that mention industrial symbiosis and its relationship to resource efficiency within the European Union, although few are specific to industrial symbiosis as a focus; rather, industrial symbiosis is included as support to their primary aims. Some of the most relevant documents are listed below:

- Official Journal of the European Union, Legislation L150, Volume 61, 14th June 2018 amendments to: Directive 1999/31/EC Landfill of Waste; Directive 2008/98/EC on Waste; and Directive 94/62/EC Packaging and Packaging of Waste.
<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AL%3A2018%3A150%3ATOC>
- DG GROW, Cooperation fostering industrial symbiosis: market potential, good practice and policy actions (2018)
http://publications.europa.eu/publication/manifestation_identifier/PUB_ET0517150ENN
- European Environment Agency: Circular Economy in Europe (2016)
<https://www.eea.europa.eu/publications/circular-economy-in-europe>
- European Resource Efficiency Platform: Short-term recommendations (2014)
http://ec.europa.eu/environment/resource_efficiency/documents/erep_manifesto_and_policy_recommendations_31-03-2014.pdf
- European Commission Communication: GREEN ACTION PLAN FOR SMEs, Enabling SMEs to turn environmental challenges into business opportunities (2014)
<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0440&from=EN>
- European Commission Communication: A Stronger European Industry for Growth and Economic Recovery, Industrial Policy Communication Update (2012) recommendation
<https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0582&from=EN>

- DG Regions: Connecting Smart and Sustainable Growth through Smart Specialisation (2012)
http://ec.europa.eu/regional_policy/en/information/publications/guides/2012/connecting-smart-and-sustainable-growth-through-smart-specialisation-a-practical-guide-for-erdf-managing-authorities
- European Commission: Roadmap to a Resource Efficient Europe (2011)
<http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0571&from=EN>
- DG Enterprise: Sustainable Industry: Going for Growth & Resource Efficiency (2011)
<https://ec.europa.eu/docsroom/documents/5188/attachments/1/translations/en/renditions/pdf>
- ETAP 10th Eco-Innovation Forum (2011)
http://ec.europa.eu/environment/archives/ecoinnovation2011/1st_forum/
- European Waste Framework Directive 'Being Wise with Waste' – Best Practice (2009)
<http://ec.europa.eu/environment/waste/pdf/WASTE%20BROCHURE.pdf>

A review of how the term 'industrial symbiosis' is used in the European institutions' documentation (legislative and beyond) has produced the following examples:

- **Council of the European Union:** Since 2013, there have been many references but only 2 occasions whereby there is an attempt to describe the term: one as a '*new business model*', and one as a '*user-driven innovation business model*'.
- **European Parliament:** There have been many references to industrial symbiosis since 2013. It is referred to as '*turning one industry's by-product into another industry's raw material*.' From the European Parliamentary Research Service, '*Industrial symbiosis engages different organisations in a network to foster eco-innovation and long-term culture change. It provides mutually profitable transactions for novel sourcing of required inputs, value-added destinations for non-product outputs, and improved business and technical processes*' citing Lombardi and Laybourn (2012a).¹
- **European Commission** – Findings are divided into the various Directorate-Generals:
 - **DG Environment:** There are several mentions of the term industrial symbiosis. Referring to NISP®, a facilitated industrial symbiosis activity: "*It is a business opportunity programme that develops mutually profitable links between traditionally separate companies from all industrial sectors and of all sizes so that previously unused or discarded resources such as energy, water and/or materials from one company can be recovered, reprocessed and re-used by other companies in the industrial member network.*" Further links to global agendas are made here: "*...with respect to industrial symbiosis, knowledge transfer and the shift towards a circular and green economy, particular attention should be given to resource efficient, environmentally-sound performance of businesses, including the value chains, and on the harmonisation of the methodology for measuring their ecological footprint.*"
 - **DG Grow:** also cites Lombardi and Laybourn (2012a)² in its 2018 report³ to encourage broader uptake of industrial symbiosis for economic benefit.

¹ Lombardi DR and P Laybourn (2012a) Redefining Industrial Symbiosis: Crossing Academic-practitioner Boundaries. *Journal of Industrial Ecology* 12(1): 28-37

² *Ibid*

³ Domenech et al. (2018). Cooperation fostering Industrial Symbiosis, Report prepared for DG Grow. Available at: <https://publications.europa.eu/en/publication-detail/-/publication/174996c9-3947-11e8-b5fe-01aa75ed71a1/language-en>

- **DG Regio:** There is an indirect definition in one of its publications, *'The Industrial Symbiosis Network helps to identify opportunities to recover and reprocess waste products from one industry that can then be re-used by other businesses. This, in turn, reduces the amount of waste going to land fill, cuts carbon emissions and creates greener jobs. In essence, it is a brokerage initiative to increase business opportunities and contribute to the sustainable growth of the region.'*
- **DG Research** describes industrial symbiosis in the text of the H2020 2014 call on waste: *'Industrial symbiosis, whereby different actors derive mutual benefit from sharing utilities and waste materials, requires large-scale systemic innovation with the aim of turning waste from one industry into useful feedstock for another one.'*
- **DG Secretary General** was responsible for coordinating the policy work that went into the circular economy package. Industrial symbiosis is communicated as: *'turning one industry's by-product into another industry's raw material'*. On a separate occasion industrial symbiosis is referred to as *'an innovative industrial process'*.

3 Terms, definitions and abbreviation

3.1 Terms and definitions

3.1.1

alternative fuel

any fuel with a potential for long-term non-renewable fuel substitution

REFERENCE: Adapted from Communication from the Commission of 24 January 2013 entitled 'Clean Power for Transport: A European alternative fuels strategy', available at <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A52013PC0017>.

3.1.2

by-product

substance or object, resulting from a production process, the primary aim of which is not the production of that item fulfilling the following points:

- (a) further use of the substance or object is certain;
- (b) the substance or object can be used directly without any further processing other than normal industrial practice;
- (c) the substance or object is produced as an integral part of a production process;
- (d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.

REFERENCE: Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives
<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098>

3.1.3

cascading use

in general, means a sequence of use phases with declining product value. Cascading allows the use of resources (materials and water) to be extended. For instance, using biomass as a production material first, then recycling it (several times) before finally recovering the energy content from the resulting waste at the end of its lifecycle. Such cascading systems may provide general advantages for climate change mitigation and ease land use pressure

3.1.4

circular economy

where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, making an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy

REFERENCE: Closing the loop - An EU action plan for the Circular Economy. COM/2015/0614 final.
<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614>

3.1.5

eco-innovation

refers to innovation that results in reduced environmental impact, no matter whether or not that effect is intended. Eco-innovation is not limited to innovation in products, processes, marketing methods and organisational methods, but also includes innovation in social and institutional structures. Eco-innovation is seen as key to achieving the transition to a sustainable economy

REFERENCE: OECD, 2009. Eco-innovation in Industry: Enabling Green Growth. Available at:
https://read.oecd-ilibrary.org/environment/eco-innovation-in-industry_9789264077225-en

3.1.6

emission

the direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources from an installation into the air, water or land

REFERENCE: The Environmental Permitting (England and Wales) Regulations 2010
<https://www.legislation.gov.uk/ukdsi/2010/9780111491423/body?view=plain>

3.1.7

energy efficiency

refers to the ratio of output of performance, service, goods or energy, to input of energy

REFERENCE: Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC Text with EEA relevance. Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1539262877283&uri=CELEX:32012L0027>

3.1.8

industrial ecology

the study of the means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural, and technological evolution. The concept requires that an industrial system be viewed not in isolation from its surrounding systems, but in concert with them. It is a systems view in which one seeks to optimize the total materials cycle from virgin material, to finished material, to component, to product, to obsolete product, and to ultimate disposal.

REFERENCE: Graedel T.E. and B.R. Allenby (1995) Industrial Ecology. Englewood Cliffs, NJ: Prentice Hall. 412 pp.

3.1.9

matchmaking

the process of identifying organisations with the potential to establish a synergy

3.1.10**material stream**

refers to the aspects of a stream as a substance mainly in terms of mass or volumetric flows

3.1.11**production residue**

refers to a material that is not deliberately produced in a production process but may or may not be a waste

REFERENCE: Guidance on the interpretation of key provisions of Directive 2008/98/EC on waste. http://ec.europa.eu/environment/waste/framework/pdf/guidance_doc.pdf

3.1.12**raw material**

the basic input material to make a product in an industrial facility

3.1.13**recycling**

any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations

REFERENCE: Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098>

3.1.14**resources**

defined by UNEP and OECD as the naturally occurring assets that provide use benefits through the provision of raw materials and energy used in economic activity (or that may provide such benefits one day) and that are subject primarily to quantitative depletion through human use. They are subdivided into four categories: mineral and energy resources, soil resources, water resources and biological resources. Resources for a business are more inclusive than just materials and equipment, including also (for example) human resources. This CWA uses 'resources' to have this breadth of interpretation

3.1.15**resource efficiency**

about ensuring that natural resources are produced, processed and consumed in a more sustainable way, reducing the environmental impact from the consumption and production of products over their full life cycles. By producing more wellbeing with less material consumption, resource efficiency enhances the means to meet human needs while respecting the ecological carrying capacity of the earth

REFERENCE: UNEP, ABC of SCP. <http://www.unep.org/scp/marrakech/pdf/ABC%20of%20SCP%20-%20Clarifying%20Concepts%20on%20SCP.pdf>

3.1.16**SPIRE**

refers to the Public-Private Partnership in the European process industries sectors of ceramics, cement, non-ferrous metals, chemicals, minerals, steel, water and engineering

REFERENCE: <https://www.spire2030.eu/>

3.1.17

synergy

the creation of an integrated whole that has a greater value than the addition of its parts. Industrial symbiosis 'synergies' are transactions where one organisation acquires underutilised resources (by-products, waste, materials, energy, water, equipment or other resources that are not the primary output of the production process) from the organisation generating them, and integrates them as inputs into their own production process. Synergies are predominantly bilateral (organisation to organisation) or multi-lateral (between many organisations) but can also be within a single organisation

3.1.18

waste

any substance or object which the holder discards or intends or is required to discard

REFERENCE: Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098>

3.1.19

Sustainable Development Goals (SDGs)

otherwise known as the Global Goals, are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. These 17 Goals build on the successes of the [Millennium Development Goals](#), while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities. The goals are interconnected – often the key to success on one will involve tackling issues more commonly associated with another

REFERENCE: UNDP, <http://www.undp.org/content/undp/en/home/sustainable-development-goals.html>

3.2 Abbreviations

CSR	Corporate Social Responsibility
CWA	CEN Workshop Agreement
OECD	Organisation for Economic Co-operation and Development
SCP	Sustainable Consumption and Production
SDG	Sustainable Development Goals
UNEP	United Nations Environment Programme

4 Core Elements of Industrial Symbiosis

Industrial symbiosis presents a systems approach to a more sustainable and integrated industrial economy which identifies business opportunities to improve resource utilisation. Industrial symbiosis 'synergies' are transactions where one organisation acquires underutilised resources (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials that are not the primary output of the production process) from the organisation generating them, and integrates them as inputs into their own production process.

The concept of industrial symbiosis in the academic literature is traced back to the seminal article by Frosch and Gallopoulos in *Scientific American* (1989)⁴ where the authors envisioned "industrial ecosystems" in which "the consumption of energy and materials is optimized and the effluents of one process serve as the raw material for another process." Several industrial sectors have incorporated similar principles into standard operating procedures for many years, including cement and chemicals.

Core elements of industrial symbiosis are the aspects that enable its identification. Elements considered core to industrial symbiosis are:

- Returning underutilised resources (often called waste) to productive use. Transactions (synergies) involving material, energy and water tend to be at the core of industrial symbiosis, but non-material resources such as expertise, capacity and logistics can be equally valuable.
- Information about opportunities (e.g., data on other organisations' resources or new technologies) is required to be able to advance a synergy.
- Business conditions incentivising industrial symbiosis, which may be through market conditions (cost reduction, risk reduction, improved competitiveness) or through policies and regulations that specify definitions (for example, waste versus by-product) and responsibilities.

Optional dimensions that may occur in some synergies and not in others:

- Collaboration through networks: A diverse network of organisations of all sectors and sizes contributes to success, as most opportunities lie outside one's own sector. Sectors including Government, third sector, research and the community each can contribute to industrial symbiosis, bringing new ideas and stimulating further activity. A formal network is not required for an actor to pursue industrial symbiosis (e.g., in the self-organised approach).
- Innovation: Often an industrial symbiosis opportunity entails innovative diversification of the business-as-usual supply chain.

Shared services: Sharing may reduce the environmental impact of the services, which is in line with the goal of industrial symbiosis, but if those services are not derived from previously underutilised resources (such as another organisation's wastewater being converted to input) then it may not be aligned with the core elements of industrial symbiosis described above.

5 Drivers for Industrial Symbiosis

Over the last decade and more, industrial symbiosis has been taken up on every continent, successfully crossing cultures and economies. Industrial symbiosis has proven successful not only in diverting waste from landfill or incineration, but also in closing the resources loop and moving waste up the value chain. The industrial symbiosis approach delivers benefits across the 3 pillars of sustainability (economic, social and environmental) and supports the delivery of a more circular economy. The European Resource Efficiency Platform championed industrial symbiosis as a mechanism for reducing carbon, preserving critical resources and securing business sustainability. It is recognised as a driver and accelerator of innovation. Recently, industrial symbiosis has gained increasing attention as a mainstream approach for

⁴ Frosch, R.A. and Gallopoulos, N.E. (1989) Strategies for Manufacturing. *Scientific American*, 261: 144-152.

helping to deliver the circular economy⁵ through the reduction of waste, emissions and primary resources consumption as priorities. The following five drivers were identified and explored at the International Working Conference on Applied Industrial Symbiosis (2012)⁶ and reinforced in the 2018 report commissioned by DG GROW “Cooperation for Industrial Symbiosis”⁷.

Economic/business impact: Generally industrial symbiosis is motivated by economic impacts delivered through mutually beneficial transactions that reduce cost or risk, generate revenue, or otherwise solve a business problem for the parties. Organisations engage in industrial symbiosis when the business case for doing so is clear – current and historical economic returns have been demonstrated in many countries. The increasing attention to sustainability and resource security issues further drives business engagement, as can a CSR agenda. At the 2015 G7 Alliance for Resource Efficiency Workshop on Industrial Symbiosis⁸, UNEP mapped industrial symbiosis to the delivery of six SDGs:

- Decent Work and Economic Growth (8)
- Industry Innovation and Infrastructure (9)
- Sustainable Cities (11)
- Responsible Consumption and Production (12)
- Climate Action (13)
- Partnerships (17).

Eco-innovation: The OECD (2012) cited industrial symbiosis as a form of systemic eco-innovation ‘vital for future green growth’, recognising its role as a catalyst for demand-led business innovation, helping to bring novel and innovative products, processes and technologies to market. DG Secretary General also refers to industrial symbiosis as an ‘innovative industrial process’.

Regional economic development: Regional economic development that draws on existing key industrial activity and resource streams can lower the carbon footprint of development, while strengthening local economies through improved material and energy security. Some regional and local governmental bodies are implementing industrial symbiosis to attract and retain businesses in their region – as in Birmingham UK, where an industrial symbiosis approach has been integrated into the economic development plan to reinvigorate the Tyseley Environmental Enterprise District. In the 10th Development Plan of Turkey, environmental protection and sustainable use of resources are among the priority goals: industrial symbiosis is defined as a strategic tool to achieve these goals in many national policy documents such as Priority Transformation Programme for Enhancing Productivity in Manufacturing, SME Strategy and Action Plan (2015-2018), National Efficiency Strategy and Action Plan (2015-2018) and National Cleaner Production/Eco-efficiency Strategy (2014-2017). It is also defined as a tool for reaching eco-efficiency and regional competitiveness objectives in regional policy documents, explicit in 19 out of 26 regional development plans prepared by Turkish regional development agencies.

Resource security: Risks associated with critical resource supply may be managed in part through managing demand, and in part through resource recovery at end of life, increasing supply. An industrial symbiosis approach is an effective means to move resources up the waste hierarchy: it reduces the use of virgin materials and water through substitution, identifies novel reuse and recycling opportunities for existing waste and by-products, diverts materials from the waste stream and prevents waste generation.

Energy security and climate change mitigation: Governments and companies around the world are focused on addressing energy concerns, both by improving efficiency (of generation, distribution, and processes), and by decarbonisation. Carbon footprint may also be reduced by cascading resources

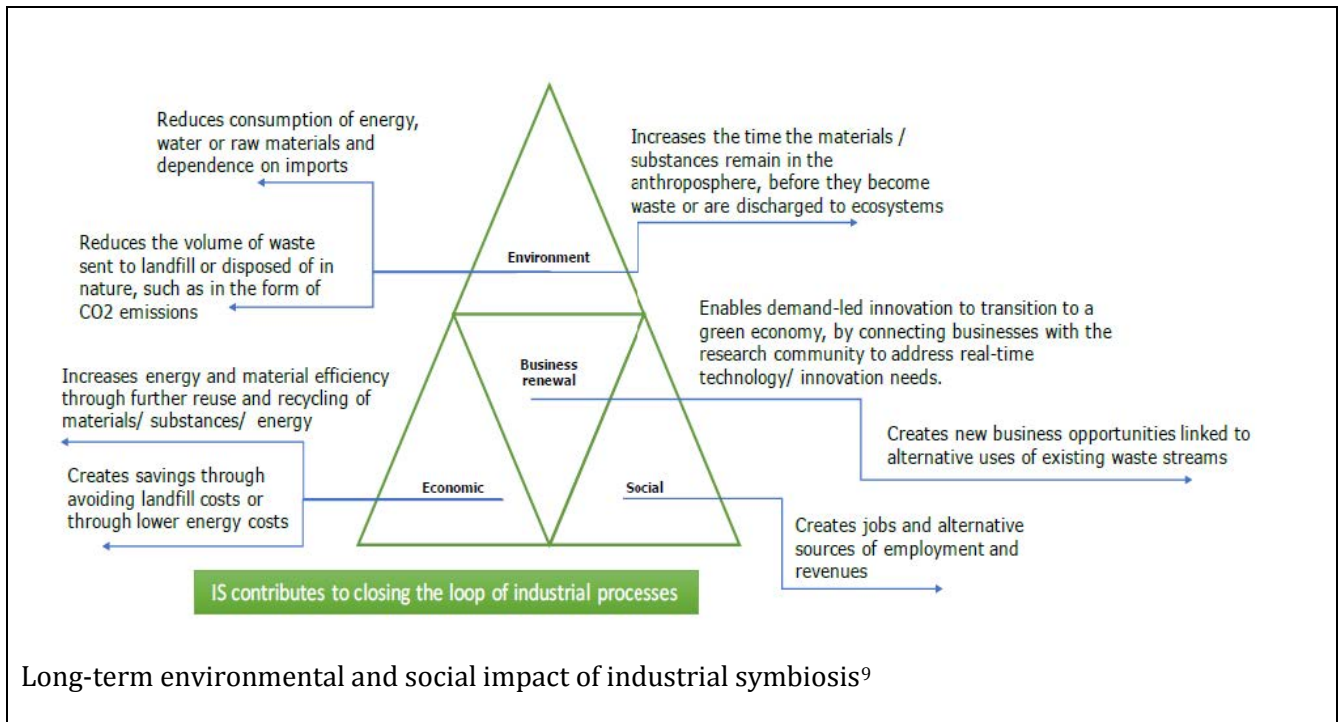
⁵ <https://www.wrforum.org/event/world-circular-economy-forum-2017/>

⁶ Lombardi D.R. and P. Laybourn (2012) *Outcomes of IWCAIS: Positive Action for Green Growth* Energy Delta Institute EDI Quarterly 4(3): 5-8. Available at: http://issuu.com/edi_quarterly/docs/edi2047_quarterly_3_okt_2012/1

⁷ *ibid*

⁸ <https://www.international-synergies.com/projects/g7-workshop-on-industrial-symbiosis/>

through multiple uses, keeping materials circulating in the economy and reducing the level of activity in extraction, refinement, transport and processing. Industrial symbiosis enables carbon reduction (including embedded carbon) through: efficiency improvements, novel fuel substitution, process innovation, heat recovery, avoided transport energy, and avoided virgin material extraction.



6 Approaches to Industrial Symbiosis NOTE

Four non-mutually exclusive approaches to industrial symbiosis have evolved. These are:

1. **Self-organised:** a bottom up approach resulting from direct interaction among industrial actors, without any external coordination, generally motivated by business concerns arising from context, including resource risk, pending legislation, and economic gains.

Self-organised Industrial Symbiosis Case study: Kalundborg, Denmark

The term industrial symbiosis has its origins in the Danish municipality of Kalundborg, the first recognized and best-known example of an industrial symbiosis network. Resource sharing by companies from different industries in Kalundborg, Denmark began because of the low availability of groundwater and the need for a surface water source which, once identified, became a key part of their resource network. The first synergies were in the 1970s, and additional synergies continued to develop into the 1980s.¹⁰ The Kalundborg self-organization was initiated by the private sector to achieve goals including cost reduction, revenue enhancement, business expansion, and securing long-term access to water and energy.

⁹ Domenech et al. (2018). Cooperation fostering Industrial Symbiosis, Report prepared for DG Grow, available at: <https://publications.europa.eu/en/publication-detail/-/publication/174996c9-3947-11e8-b5fe-01aa75ed71a1/language-en>

¹⁰ Ehrenfeld J. And N. Gertler. 1997. Industrial Ecology in Practice: The Evolution of Interdependence at Kalundborg. *Journal of Industrial Ecology* 1(1):67-79.

2. **Facilitated:** where a third-party intermediary coordinates the activity, working with organisations to identify opportunities and bring them to fruition. Industrial symbiosis practitioners play the critical role of facilitating and co-ordinating the contributions of the various stakeholders. By engaging with organisations from all sectors, the practitioner enables the flow of information across sectoral boundaries; practitioners often provide technical support to overcome technical or regulatory barriers associated with synergies.

Facilitators come from the private sector (as in NISP England), the public sector (for example, City of Manresa, Spain; Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) Italy), academia (for example, Erasmus University Rotterdam, Netherlands), or the third sector (for example, GreenCape, South Africa). In all cases, the investment is in their time to build a network, gather information, and facilitate synergies to completion. At least for NISP England (2005-2010), the public investment returned a benefit cost ratio of between 32 and 53 to 1.¹¹ These activities can be directed to achieve specific targets: for example, if success is determined by achieving substantial landfill diversion, then target sectors are likely to include construction, cement, and foundries for the large volumes of materials mobilised. If instead the key metric is innovation, the coordination focuses on attracting entrepreneurs and innovators.

Facilitated Industrial Symbiosis Case study: NISP®

The most cited facilitated approach to industrial symbiosis in European policy is the NISP® methodology. First developed in the UK by International Synergies Ltd, it has since been replicated in over 20 countries on 5 continents. The NISP model involves expert facilitators (practitioners) gathering information from companies, making expert assessments, then identifying and facilitating synergy opportunities through to completion. The success of NISP has inspired many parties to implement industrial symbiosis across Europe: current activity largely comprises regional efforts supported by public-sector investment. This holistic approach has demonstrated *in practice* verified positive impacts including cost reduction, additional sales; reduction in materials, water and energy use; innovation, knowledge transfer and best practice sharing, capacity utilisation, and job creation.

3. **ICT-supported:** Part of the challenge of industrial symbiosis in practice is that most opportunities for a given organisation lie outside one's own sector. Decision-makers in industry today will have experience deriving primarily from a single industry; going outside one's own sector, and traditional supply chain, requires support. This market failure of information in relation to resource efficiency can be addressed through mechanisms that improve information flow between actors.

The concept of ICT to support industrial waste reuse dates back to the 1970's when information exchanges were first established. More recently web-based waste exchanges have proliferated as the technology has developed. Passive online waste exchanges have had very limited uptake in Europe and around the world, which is attributed to their inability to meet the specific information needs of industrial users (including classification, contamination, distribution and timing issues) and the lack of mainstream buy-in to industrial symbiosis.

¹¹ Scott Wilson Business Consultancy and Manchester Economics. 2009. NISP Economic Evaluation Report. October.

ICT-enabled Industrial Symbiosis Case study: SYNERGie®4.0

International Synergies Limited SYNERGie®4.0 system bespoke to industrial symbiosis support. SYNERGie®4.0 delivers resource database, project management, impact reporting and customer relationship management functionalities, and is proven in practice hosting over 40,000 resources from over 20,000 companies worldwide. The most established ICT system supporting industrial symbiosis has been developed by practitioners to support their activity, and then extended to more general (non-expert) use.

4. **Strategic or planned:** a top-down approach where networks are formed following a central plan or strategic vision that includes attracting new businesses to regeneration sites or purpose-built developments. Industrial symbiosis in existing enterprise/commercial zones is based on existing resource flows, infrastructure and economic activity; the analysis identifies opportunities for strategic economic development that increases the productivity of existing resources, reduces carbon emissions, and attracts new investment and green business growth through industrial symbiosis. The approach has been applied to existing industrial parks and industrial areas of a city.

Planned Industrial Symbiosis Case study: Sustainable Devens (USA)

The Massachusetts economic development agency converted a former military base in Devens into a planned community and gave the Devens Enterprise Commission (DEC) the mission to integrate into its development and management the principles of sustainable development and industrial ecology (including industrial symbiosis).

Businesses operating in the Devens eco-industrial area are largely SMEs in the sectors of high tech, logistic, manufacturing, etc. The programme aims at fostering networking and environmental commitment among onsite and other local firms. DEC's environmental policy criteria include by-products and information exchanges, joint purchasing, recycling, sustainable building, reduced use of toxic chemicals, mutual aid to reach standards, etc.

Case study source: Massard et al (2014)

Information: <http://www.devensec.com/sustain.html>

These approaches are not mutually exclusive: Kalundborg was self-organised until 1996 when a coordinating organization, the Symbiosis Institute, was launched as part of Kalundborg's industrial development agency to accelerate the number and complexity of new synergies. NISP® in England was facilitated throughout its life but started without ICT support in its early days. ICT enabled approaches may or may not include facilitation. Strategic/planned approaches may involve facilitators and/or ICT support.

7 Industrial Symbiosis Implementation: Good Practice

7.1 Factors Enabling Good Practice

- Facilitation (through full time or substantial commitment) is necessary to advance synergies to completion.
- Public sector investment has led to macro-economic impact which contributes to the economy as a whole through multiplier effects and has proven value for money/return on investment.¹²
- A policy enabling context supportive of industrial symbiosis does not introduce legislative or regulatory barriers to industrial symbiosis, but rather incentivises it.
- Advancing synergies (with or without facilitation) requires an investment on the part of the organisations involved, in time if not capital. The communication of industrial symbiosis must be clearly focused on the benefits to be derived from the activity to gain the organisation's buy-in and investment.
- ICT (software) supports data management and impact tracking to overcome information barriers to industrial symbiosis.
- Industrial diversity in a region enhances the chance for industrial symbiosis¹³ as most (not all) reuse opportunities are outside one's own sector.
- Various factors determine how far a resource will travel, including the market (price, cost), regulation and legislation: in England, documented NISP® synergies have moved textiles, metals, minerals and paper/card over 200 miles.¹⁴ Steam and heat synergies are limited to local opportunities.
- A diverse network engaging business across all sectors and sizes, research and the government has proven to foster knowledge transfer and demand-led innovation by bringing together the companies with real problems, and the researchers able to address, and sometimes resolve, them. In the UK's NISP experience, over 70% of synergies have been shown to involve some form of innovation: 50% cross-sector knowledge transfer and best practice, and 20% new research and development deriving from close links with universities.
- A clear monitoring and evaluation framework established from the beginning of activity will provide the relevant information for assessing return on investment (for public sector, most common) and capturing the economic, environmental and social impacts.
- Targets and constraints drive activity: where desired outputs are defined in goal-directed approaches, then effort will first be directed to those sectors/materials that are most likely to deliver the priority outputs (be they environmental, economic or social, or any subset thereof).

¹² Scott Wilson Business Consultancy and Manchester Economics. 2009. NISP Economic Evaluation Report. October.

¹³ Jensen P.D. (2016) The role of geospatial industrial diversity in the facilitation of regional industrial symbiosis. **Resources, Conservation and Recycling** 107 (Feb): 92-103. <https://doi.org/10.1016/j.resconrec.2015.11.018>

¹⁴ Jensen P. D., Basson L., Hellawell E. E., Bailey M. R. and Leach M. (2011) Quantifying 'Geographic Proximity': Experiences from the United Kingdom's National Industrial Symbiosis Programme. **Resources, Conservation and Recycling** 55(7): 703-712. <https://doi.org/10.1016/j.resconrec.2011.02.003>

7.2 Actions Representing Good Practice

- Fully characterise the resources available: think broadly about resources (including waste, by-products, residues, energy, water, logistics, capacity, expertise, equipment and materials); and reassessing waste for value as a resource.
- Identify and assess opportunities to return underutilised resources to productive use: statistically, most (not all) reuse opportunities are outside one's own sector, so employ cross-sector knowledge as required.

Match the available resource with the appropriate opportunity, addressing technical, economic, and legal requirements. Intermediate transformation steps may also be required.

Bibliography

List of references

Domenech et al. (2018). Cooperation fostering Industrial Symbiosis, Report prepared for DG Grow. Available at: <https://publications.europa.eu/en/publication-detail/-/publication/174996c9-3947-11e8-b5fe-01aa75ed71a1/language-en>

Frosch, R.A. and Gallopoulos, N.E. (1989) Strategies for Manufacturing. **Scientific American**, 261: 144-152.

Jensen P. D., Basson L., Hellowell E. E., Bailey M. R. and Leach M. (2011), Quantifying 'Geographic Proximity': Experiences from the United Kingdom's National Industrial Symbiosis Programme. **Resources, Conservation and Recycling** 55(7): 703-712.

Lombardi D.R. and P. Laybourn (2012) Redefining Industrial Symbiosis: Crossing Academic-practitioner Boundaries. **Journal of Industrial Ecology** 12(1): 28-37

Lombardi D.R. and P. Laybourn (2012) *Outcomes of IWCAIS: Positive Action for Green Growth* **Energy Delta Institute EDI Quarterly** 4(3): 5-8. Available at: http://issuu.com/edi_quarterly/docs/edi2047_quarterly_3_okt_2012/1

Massard G., Jacquat O., Zürcher D. (2014) *International survey on eco-innovation parks. Learning from experiences on the spatial dimension of eco-innovation*. Federal Office for the Environment and the ERANET ECO-INNOVERA, Bern. Environmental studies no. 1402: 310 pp. Available at: <https://is4ie.org/resources/documents/5>

Appendix 1: Case studies

DECHEMA Technology Study 2017, Low carbon energy and feedstock for the European chemical industry. Available at: https://dechema.de/dechema_media/Downloads/Positionspapiere/Technology_study_Low_carbon_energy_and_feedstock_for_the_European_chemical_industry-p-20002750.pdf

European Circular Economy Stakeholder Platform: <https://circulareconomy.europa.eu/platform/>

Fertilizers Europe 2016, Circular Economy and industrial Symbiosis. Available at: http://www.fertilizerseurope.com/uploads/media/Circular_Economy_01.pdf

G7 Alliance for Resource Efficiency (2015) Report on Industrial Symbiosis Workshop available at: <https://www.international-synergies.com/projects/g7-workshop-on-industrial-symbiosis/>

Laybourn, P. and M. Morrissey. (2009) *National Industrial Symbiosis Programme: The pathway to a low carbon sustainable economy*. Kings Norton, UK: International Synergies Ltd

Massard G., Jacquat O., Zürcher D. (2014) *International survey on eco-innovation parks. Learning from experiences on the spatial dimension of eco-innovation*. Federal Office for the Environment and the ERANET ECO-INNOVERA, Bern. Environmental studies no. 1402: 310 pp.

The World Bank Group (2018) A Practitioner's Handbook for Eco-Industrial Parks: Implementing the International EIP Framework. Available to download here: <https://openknowledge.worldbank.org/handle/10986/30458>

Case Study, Construction and Demolition Waste as input to Cement Manufacture: <https://www.lafargeholcim.com/austria-construction-waste-recycling>

[Case study, Wood Waste as Fuel Substitute for Cement Manufacture:](https://www.lafargeholcim.com/austria-construction-waste-recycling)

<https://circulareconomy.europa.eu/platform/en/good-practices/development-deconstruction-wood-waste-use-energy-recovery-cement-plants>

[Case study, Alternative Raw Material inputs to Cement Manufacture:](https://www.lafargeholcim.com/austria-construction-waste-recycling)

<https://circulareconomy.europa.eu/platform/en/good-practices/cement-industry-protecting-natural-resources-reusing-alternative-materials>

Horizon 2020 project EPOS *Interim Report - September 2015 to March 2017*. Available at:

https://www.spire2030.eu/sites/default/files/users/user222/Epos-docs/Public%20Summary_0.pdf

Horizon 2020 project FISSAC Report, Identification of best practices and lessons learnt in industrial symbiosis. Available at: <http://fissacproject.eu/wp-content/uploads/2018/06/FISSAC-D1.2-Best-practices-and-lessons-learnt-in-IS-Summary.pdf>

Horizon 2020 project MAESTRI Report, Prototype library of case studies linked to a waste database. Available at: https://maestri-spire.eu/wp-content/uploads/2018/01/MAESTRI-D4_2_v1_rev.pdf

Appendix 2: Indicators

The following reports address the status of indicators for industrial symbiosis:

Domenech et al. (2018). Cooperation fostering Industrial Symbiosis, Report prepared for DG Grow, available at: <https://publications.europa.eu/en/publication-detail/-/publication/174996c9-3947-11e8-b5fe-01aa75ed71a1/language-en>

Horizon 2020 project FISSAC Report, Identification of best practices and lessons learnt in industrial symbiosis. Available at: <http://fissacproject.eu/wp-content/uploads/2018/06/FISSAC-D1.2-Best-practices-and-lessons-learnt-in-IS-Summary.pdf>

Horizon 2020 project FISSAC Report, Industrial Symbiosis Indicators. Available at: http://fissacproject.eu/wp-content/uploads/2018/10/FISSAC_D1.6_Indicators_P11_16092016_FINAL_1.pdf

Appendix 3: Supplementary Guidance

Domenech, T., Doranova, A., Roman, L., Smith, M., Artola, I. et al. (2018). Cooperation fostering Industrial Symbiosis: Market potential, good practice and policy actions, Report prepared for DG GROW. Available at: <https://publications.europa.eu/en/publication-detail/-/publication/174996c9-3947-11e8-b5fe-01aa75ed71a1/language-en>

Horizon 2020 project FISSAC Report, Initial outline of FISSAC industrial symbiosis model and methodology. Available at: <http://fissacproject.eu/wp-content/uploads/2017/09/FISSAC-D1.8-Initial-outline-of-FISSAC-IS-Model-Methodology.pdf>

Horizon 2020 project Maestri Report, User guide for getting started with industrial symbiosis. Available at: https://maestri-spire.eu/wp-content/uploads/2018/01/MAESTRI-D4_4_v1.pdf

Horizon 2020 project Maestri Report, Toolkit for industrial symbiosis. Available at: https://maestri-spire.eu/wp-content/uploads/2018/01/MAESTRI-D4_3_v1_rev.pdf