IDENTIFYING AND ASSESSING INDUSTRIAL ECOLOGY OPPORTUNITIES IN MELBOURNE

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ABSTRACT

Industrial ecology approaches offer opportunities to reduce potable water resource dependence in Melbourne. The purpose of this project is to outline a framework for identifying and selecting priority Industrial Ecology opportunities – incorporating resource exchange between industrial customers in Melbourne. This paper includes a discussion of the initial outcomes and possible future directions for this project, and the field of Industrial Ecology more broadly. It is currently being lead by the Institute for Sustainable Futures, UTS together with collaborators from the University of Melbourne, RMIT and Curtin University supported by the Victorian Smart Water Fund.

INTRODUCTION

Industrial ecology and resource recovery approaches are becoming increasingly important within industry as a result of water scarcity, rising costs of water, tightening controls on pollutant loads released to Port Phillip Bay and the possibility for new discharge standards linked to the recent Trade Waste Review in Victoria.

Internationally, Industrial Ecology is gaining momentum as a concept in response to global resources constraints, - particularly energy, water and minerals - and a growing need for companies to show that they are responding to these challenges.

The Institute for Sustainable Futures (ISF) and collaborating partners were commissioned by the Smart Water Fund to conduct research into Industrial Ecology opportunities in Melbourne.

The project began in 2007, and has to date incorporated a wide range of activities, including modelling and stakeholder workshops with large water users in Melbourne to identify needs, and with industrial parks such as Port Melbourne to further explore specific opportunities.

The key objective of the study is to identify specific short to medium term opportunities for reducing the impact of wastewater from industrial systems in Melbourne through the cycling of resources between firms.

The focus is on reducing the impact of the industrial sector (in preference to, for example, agriculture) and must be feasible to be implemented within 5 years. The nature of opportunities will be recycling of industrial wastewater into other industrial processes, or from existing wastewater treatment plants into industrial processes.

The steering committee for the project also identified a number of context specific contaminants that are of particular concern in the Melbourne region. The contaminants include Cadmium, Mercury, Copper, Zinc, Total Dissolved Solids, Colour and Boron. Therefore reductions in sewer discharge of these contaminants as result of the industrial ecology opportunities identified in this study would strengthen the case for implementation of these options.

Initially, a literature review was conducted of international examples of Industrial Ecology, and of available tools and methodologies. The literature review has informed the choice of tools to be used later in the project.

A process was established for the planning of Industrial Ecology opportunities, and this flexible planning framework has the potential to be replicated across other cities or other sites in Melbourne.

The project is ongoing, preliminary investigations have also been conducted at industrial sites in Melbourne, and initial results are described in this paper.

BACKGROUND TO THE PROJECT

What is Industrial Ecology ?

Industrial Ecology is a collection of concepts and approaches that seek to reduce the impact of industrial systems, primarily through the adoption of cyclical principles of resource use present in natural systems. The field looks for 'natural' models to provide a template for designing or re-designing industrial systems at the sectoral scale (Frosch and Gallopoulos, 1989). Ecological concepts such as closing the loop, adaptation and resilience are used to guide approaches used to lead to improved sustainability of industrial processes.

Lifset and Graedel (2002) outline five of the core elements of the field of Industrial Ecology as :

- The biological analogy;
- The use of systems perspectives;
- The role of technological change;
- The role of companies; and,
- Dematerialisation.

In practice, this involves reorganising supply chain processes at the firm or sectoral level to achieve environmental outcomes through, for example, resource exchange and recycling. A conceptual model at the sectoral scale is shown in Figure 1.

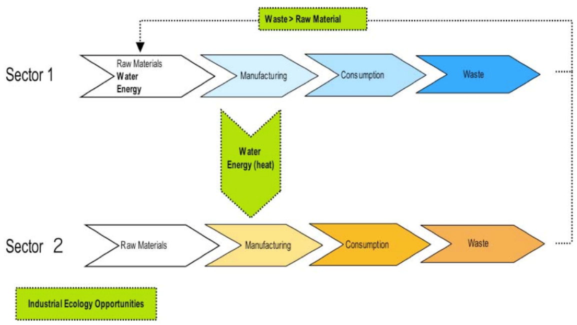

Figure 1 Conceptual diagram of an industrial ecology opportunity

Examples of this model in practice could be the reuse of metals from industrial wastewater, or the use of excess steam and heat from industrial processes to heat water.

Case Study of Industrial Ecology

The most notable example of Industrial Ecology in practice in Australia is the Kwinana Industrial Area (KIA) in Western Australia. The KIA was established in the 1950's to secure an area of 120 km^2 for the accommodation of major resource processing industrial estate in Western Australia.

Today, the total economic output of the region is approximately $4.3 billion annually (SKM, 2002) and is recognised as the cornerstone of the Western Australian economy.

In 1991, the Kwinana Industrial Council (KIC) was established to manage environmental impacts of the KIA, particularly impacts on the highly sensitive nearby marine environment. The initial tasks were monitoring of air and water qualities.

The role of the KIC has since expanded substantially and now addresses a broad range of issues including water efficiency, consumption, discharge and recycling. Several water conservation and recycling initiatives have been implemented including the Kwinana Water Reclamation Plant and on site efficiency assessments.

There are currently 47 synergy projects in place where either water, energy or industrial process stream by-products are recycled back into the industrial systems. One example of this is the reuse of recycled effluent at the alumina refinery, where treated wastewater is used in the process circuit for the Aluminium plant (van Beers *et al.*, 2007).

The key to development of regional water synergies at Kwinana is that there is an overall net benefit from the synergy without any of the stakeholders being disadvantaged. Beneficial sustainability outcomes have included water conservation, improved quality of discharge waters and reduced energy consumption. Further, these synergies have reduced the vulnerability of industry to future droughts and have led to strategic benefits such as a better reputation with stakeholders. Insights from the Kwinana experience were shared by Dick van Beers who works on regional synergies in Kwinana, at the workshop with Melbourne stakeholders organised through our current project.

PROJECT OUTCOMES

The Industrial Ecology research project in Melbourne has resulted in a number of outcomes to date, including:

- A literature review of available tools and methodologies;
- A review of critical success factors and stakeholder workshops to identify key barriers and enabling factors in the field;
- A process for developing a flexible planning framework for proceeding with opportunities once a suitable site has been selected; and,

- Preliminary analysis of selected sites has also been conducted (results are shown below) which will be further developed into a scoping study of the opportunity, detailing costs and benefits.

Available tools and methodologies

A range of tools were reviewed with a view to identifying tools appropriate for this study. These are discussed further in the project Literature Review (Kazaglis *et al.*, 2007) and the application of a specific tool for modelling a case study is described later in this paper.

Critical success factors

Recent reviews of international case-studies identified certain aspects as central to successful industrial ecology synergies (van Berkel, 2006; Heeres *et al.*, 2004):

- The use of proven technology;
- A convincing business case;
- Licence to operate from the community;
- Active participation of companies in planning;
- Financial commitment of companies;
- Begin with simple high benefit, low cost utility sharing projects,
- Once relationships are established, tackle more challenging projects, still with economic and environmental benefits .

Many overseas examples of industrial ecology have taken place within Eco -Industrial Parks, such as in Denmark, the Netherlands, the US, China and Australia. These studies emphasised that projects that began with small utility sharing projects between businesses often manifested into much larger recycling and reuse schemes that developed over decades.

This type of development is contrasted with those which begin with localised waste exchanges, which were limited in their long term sustainability (Heeres *et al.*, 2004).

Trust and relationships between companies were also identified as critical to success, as is reflected in the case of Kwinana and the establishment of the KIC.

Planning framework for Industrial ecology

An over-arching planning process was established to guide the analysis once an Industrial Ecology opportunity has been selected. This process is necessary because often there are multiple options for Industrial Ecology at any one site, and there may be little existing data or information to distinguish between them.

The outputs of this planning process are a report of the costs, benefits and a range of qualitative criterion of a range of options at a site. These can then feed into decision making regarding future investment in industrial ecology.

The generic steps in the process include:

- Establish project objectives and scope;
- Gather data and information;
- Select appropriate tools for analysis and undertake modelling;
- Deterring criterion and conduct assessment of the project; and,
- Proceed with project.

This process, whilst flexible enough to be adopted at different locations, provides specific guidance by asking key questions at each step. These questions streamline the process of analysis by confronting the most common challenges upfront, such as data needs and availability. These questions include:

- What is the scope of outputs required, i.e. individual site level or broader? This will influence which analytical tools are selected.
- What input data is available on the site of interest? Has monitoring been conducted in the past? Is further monitoring needed?
- What criterion best indicates whether the project will achieve its objectives? Are these criterion measurable? Figure 2 contains a short list of possible criterion.

Criterion	Description	Units
Reduction in water use	The water savings that would be achieved	kL/annum
Reduction in energy use	The energy savings that would be achieved	MW/annum
Reduction in pollutant concentration	The change in concentration of pollutants of interest	% change in concentration
Capital cost of project to all stakeholders over lifecycle	This includes all modifications and construction to occur	$ NPV over 50 years
Operating cost of project to all stakeholders over lifecycle	This includes the total cost of running and maintaining the project including energy and personnel costs	$ NPV over 50 years
Increase to public amenity	This may be appropriate if the site of interest includes public spaces	Star scale out of five
Innovation	It may be necessary to showcase new technologies in the project in order to achieve an icon status to achieve funding	Star scale out of five
Replicability	The project may be required to be rolled out to other sites and jurisdictions	Star scale out of five

Figure 2 Shortlist of possible criterion for decision making (Giurco et al., 2007)

Preliminary analysis of selected sites

Detailed modelling is required in order to evaluate the benefits and costs of the projects and to begin to scope the possibility of a business case. Often detailed modelling may be limited by the availability of data, particularly if sub-metering of water consumption and other parameters is not available at the site. Back-of-envelope assumptions for flows and costs can provide an important initial picture, and can highlight the areas that require further probing.

The dynamic Simulink model was used to assess one of these opportunities in detail. The dynamic system model uses Simulink software (for product information, refer to MathWorks Inc. 2007), a The application of industrial ecology concepts result in reduced water consumption, reduced discharge of BOD to sewer, and reduced cost of wastewater discharge, without affecting production rates of either plant. Various different scenarios are simulated, to ensure a technically robust scenario for resource exchange is created, which can withstand dynamics such as temporary operational changes in some plants, fluctuating flow rates and water quality, and permanent changes to capacity of one or more plants in the system.

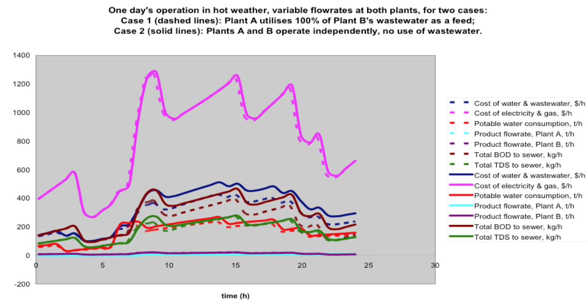

Figure 3 Results from Simulink software

Figure 3 shows how the Simulink software can be used to show how the reuse of wastewater between the companies reduces the costs associated with water and wastewater, concentrations of BOD and potable water.

Currently further investigation is being conducted at Port Melbourne involving several co-located companies. Initial discussions suggest that this may be a useful site for detailed assessment as:

- Companies have expressed that there is a likely commercial incentive at the site; and,
- Companies have expressed that with rising costs of water, they can see a potential business case.

A forthcoming scoping study of this site will explore this potential opportunity in more detail.

process control simulation package that operates within MATLAB.

An example of the type of results from the dynamic Simulink model is shown in Figure 3. This graph shows water and other utility costs, and various material flow rates through two fictional chemical plants, A and B. Two cases are shown, the current case, in which both plants operate independently (solid lines), and the case in which Plant B uses the wastewater of Plant A as its source of process water (industrial ecology opportunity).

THE POTENTIAL FOR INDUSTRIAL ECOLOGY TO ACHIEVE ENVIRONMENTAL GOALS

Industrial Ecology is an emerging field, and while there are many case studies to support initial optimism, there is limited experience with the potential for Industrial Ecology approaches to directly inform policy tools that could be used by Governments.

To sustain environmental outcomes, monitoring and evaluation mechanisms are crucial. In other words, companies must be able to demonstrate quantifiable sustainability benefits to have license to show sustainability in the public sphere. This may be a particular concern if companies are pursuing corporate social responsibility objectives in the absence of other drivers, such as pollution control or the reduction of water and energy bills. Industrial Ecology is also limited by the fact that the most successful examples to date have emerged 'organically', over the long term and as a result of ongoing and effective collaboration. This is the case primarily because trust between companies is an enabling factor for opportunities being pursued. This highlights the role that trust-building should play in supporting favourable short-term business cases for industrial ecology opportunities.

Further to its role in improving efficiency between existing companies, Industrial Ecology has even greater potential in new developments, such as new industrial parks. Industrial Ecology principles can be embedded into the terms of reference for locating in a new industrial park. This would result in companies that have environmental goals as central to their long term strategy being attracted to move to these areas, or in existing companies being encouraged to adopt more sustainable approaches.

CONCLUSION

Industrial ecology concepts are being applied in Melbourne to identify new project opportunities for resource exchange and recycling between industrial firms. The scope of this project is directed towards existing industrial customers, with a focus on cycling of water and wastewater.

A range of tools have been assessed, and a methodology developed that involves both whole-of-city scale and sectoral scale assessments. For the sectoral scale assessment, two priority opportunities are being explored, at Laverton and Port Melbourne and further data collection and modelling is being undertaken to develop a scoping study of these opportunities.

In addition to the potential to improve outcomes in existing areas, a necessary future focus must be on incorporating the industrial ecology approach to the design and operation of new industrial developments.

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