Centre for Sustainable Resource Processing

Project 3B1: Capturing Regional Synergies in the Kwinana Industrial Area

Capturing Regional Synergies in the Kwinana Industrial Area

2010 Summary Report

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1. OVERVIEW

The research project ‘Capturing Regional Synergies in the Kwinana Industrial Area’ (or also known as Kwinana Synergies Project) has been initiated to support the further development and implementation of profitable exchanges of by-products, water, energy, and services between industrial operations in the Kwinana Industrial Area (KIA). The project assists the industries in Kwinana to achieve greater efficiencies in energy, water and materials consumption and reductions in waste and emission generation. The project provides practical support to the companies in the Kwinana region, to develop, evaluate and implement synergy opportunities, and communicate the gains in the overall eco-efficiency of the area. Even though earlier initiatives were taken within the framework of the establishment of the Centre for Sustainable Resource Processing (CSRP), the project formally commenced in March 2004.

This summary report provides an overview of the findings and progress made in the period from July 2009 to June 2010 of the Kwinana Synergies Project. The research is being conducted by Curtin University of Technology (a core participant in the CSRP) through its Centre of Excellence in Cleaner Production (CECP) in close collaboration with the Kwinana Industries Council (KIC, an associate participant of CSRP). This summary report follows the status reports 2004-08 of the Kwinana Synergies Project (van Beers 2006; Van Beers 2007; Van Beers 2008; van Beers, Bossilkov et al. 2005) ad the Summary report 2009 (Bossilkov 2009).

2. Evaporative Water Treatment Technologies – Preliminary Assessment for Kwinana Industrial Area (Project 125)

The CSRP Kwinana Synergies Project delivered a scoping study on energy recovery from Kwinana flue gases. It revealed that the total energy release from Kwinana flue gases is estimated at approximate 6,300 TJ/yr, with up to 3,000 TJ/yr over 300°C. The flue gas study created interest from Kwinana industries to investigate the business and sustainability case to produce fresh water from seawater (desalination) or industrial effluents, utilising the energy embedded in industry flue gases.

Initial estimates by a Kwinana company show that very significant amounts of fresh water (over 50 GL/yr) could be produced from the available flue gases energy. The desalinated seawater could be supplied to the Water Corporation as drinking water.

Following up on recommendations of the KIC Energy Workshop held in May 2006, the CSRP 3B1 Kwinana Synergies Project produced a scoping study on energy recovery from Kwinana flue gases. This work highlighted the significant potential to explore sustainable uses for these flue gases. Through discussions in the KIC Eco-Efficiency Committee, the opportunity was identified to produce significant amounts of fresh water from available industry flue gases.

Seawater desalination is a process for converting seawater into pure water which has developed considerably over the past four decades. There are few commercially available processes for seawater desalination: reverse osmosis (RO) that uses membrane to separate salts from the seawater, and the thermal processes that evaporate seawater and then condense the evaporated water into fresh water. Desalination is an energy intensive process. The energy cost contributes 25% – 40% to the total cost of desalted water (Raha, Srivastava et al. 2007). Different sources of energy including coal, gas, solar, waste heat, in the form of either heat or electricity, can be used to operate the desalination process.

The CSRP Kwinana synergy project on energy recovery from flue gases estimated that the total amount of energy release from Kwinana flue gases would be 6,300 TJ/year. A techno-economic feasibility study needs to be carried out to assess the potential recovery of heat from flue gases to desalinate seawater in Kwinana Industrial Aria. Project 125 (Stage 1a) investigated only the preliminary assessment of possible desalination and evaporation technologies for thermal processes that can use waste heat from Kwinana flue gases to evaporate seawater for desalination purposes. It reviewed all major commercial processes for desalination and/or evaporation (presented in Table 2-1) suitable for low temperature application, as well as a considerable number of promising alternative processes, either proven, demonstrated or still in R&D stage. A brief summary of the processes coupled with significant issues is also included in the table.

Table 2-1: List of the reviewed technologies

Option	Summary + specific issues or characteristics
Multi-stage Flash Distillation	MSF accounts for over 40% of the world's desalination capacity. Requires high feed temperatures and it's not suitable for use with waste heat. MSF with a heat recovery system (HRS) is still in R&D stage.
Multi Effect Evaporation Desalination system	Proven technology with relatively high capital cost Operating costs can be reduced and recovery rate increased if brackish water is used for feed
Hybrid RO Multi-stage	Not much data for the Hybrid option. Lower capital costs than

Option	Summary + specific issues or characteristics
Flash Distillation	MEE, similar operating costs and higher recovery rate. Recovery rate could be increased if brackish water iis used as feed.
ECOVAP	No data on costs. Evaporation process resulting in dry residue.
Low Temperature Evaporation	Very low recovery rate. Very high capital and running costs. All the costs are cited in literature in Indian currency and present exchange rate was use to convert, which might have affected these. It has a small land requirement and it produces extremely high quality water. It may be worth investigating whether the cost would reduce (and recovery rate increase) with reducing the quality of the produced water.
Diffusion Driven Desalination	Very low recovery rate. On the other hand very low operating costs. These figures are estimated. Not proven technology.
Dewvaporation	Modular design (towers) less footprint compared to RO, MEE, MSF. Cheapest option to construct and run, compared to the options that have data available. Very high recovery rate, achieving dry output. This process could use different qualities of feed water but it could be specifically useful if spent cooling sweater or the desalination plant reject water is used for feed, as it has been demonstrated that can treat 10,000 ppm of TDS concentrated waste water feed and 45,000 ppm TDS brines with minimal reduction in production rate.
Low Energy Distillation	40% more efficient that RO, but not much information. Not a proven technology.
RSE - Rapid Spray Evaporation	Portable units able to be scaled up. Very high recovery rate, up to 100% with dry output. RSE is capable of treating feed solution that has TDS four times greater than the sea water.
Thermal Distillation	Rather high capital costs, no data for operating costs.
Aquastill	Modular design, with small footprint. Capital costs lower than MSF, MEE and RO, with relatively low operating costs.
Adsorption (AD) Water Desalination	Not much information, pilot study at present. Commercialisation expected before 2011.
Synthermic waste heat evaporators	No brine, dry disposal. No data on costs. Use low temperature, otherwise unusable waste heat, and can treat fluids with up to 320,000 ppm TDS, as well as high levels of suspended solids.
Water desalination by humidification and dehumidification of air	No data, but reportedly cost is not competitive with RO and MSF.
Forward Osmosis	Relatively low running costs, no data on capital costs. Pilot study at present. Not a proven technology.
Low temperature Thermal Desalination	

The objective of this preliminary assessment was to address the identification of suitable technology for the treatment of sea water or industrial effluent that would allow the production of adequate quantities of water with desired quality. The identified technologies were assessed based on assessment criteria listed below were, the later designed to assist the KIA industries in identifying the potential location, size and choice of technology in terms of performance and costs:

- Required capacity
- Suitability of a heat source (type, heat content, T)
- Land availability and location
- Capabilities
- Estimated capital costs
- Estimated operating costs
- Recovery rate
- Specific characteristics and issues
- Supply and availability

The above preliminary assessment criteria presented in this report were used to identify a suitable desalination/evaporative technological option/s. A draft report coupled with a questionary was sent to the members of the Eco-efficiency committee at KIC, requesting them to list their first 3 preferences in evaporative/desalination water treatment method in terms of capability, recovery rate, estimated capital and operating costs, as well as to identify land availability and its location.

Despite the disappointing low number of responses by the industry partners, there has been general consensus with regard to the choice of technologies. The results of the industry consultation are summarised below:

- Three potential sites were identified, (1) close to a suitable heat source at Alcoa, (2) east of BP refinery close to a suitable heat source at BP; and (3) a site to the west of Nickel West refinery.
- The three preferred technologies in regard to capability, capital and operating costs were Hybrid RO, MEE and Thermal, and in regard to the recovery rate preference was given to MEE, Hybrid RO and RSE technologies. Generally the respondents commented that technology selection should be based not only capital and operating costs and capability to meet demand, but also preference should be given to less complex and most importantly proven technology.

As a continuation of Stage 1a of project 125, a number or options for a demonstration desalination plant are outlined in Chapter 4.

3. REVIEW OF CURRENT LEGISLATION FOR WATER RECYCLING AND REUSE (PROJECT 126)

In 2006 the Kwinana Industry Council (KIC) engaged Burns and Roe Worley to undertake a water planning study for the Kwinana Industrial Area (KIA) to identify sustainable options for water supply, wastewater reuse and disposal. This study estimated the total water demands from the KIA at 32.7 GL/yr, and projected an increase to 69.6 GL/yr by 2021. The study revealed that preferred water sources based on available quantities and source cost estimates are:

- groundwater
- secondary treated wastewater (high or low quality)
- aquifer recharge, and
- effluent exchanges as recommended by a CSRP water synergy scoping study.

Water uses include potable water use, cooling water, process water, wash down water, steam cogeneration, dust suppression and slurry transport. A variety of water qualities can be utilised in each water use. The State Water Strategy adopts the concept of using water that is ‘fit for purpose’, i.e. high quality drinking water should be used only for drinking and other personal uses, but not necessarily for purposes where alternative water sources can be safely used. Quantity and quality of ‘fit for purpose’ water demands in the KIA however, are not well known. Currently main water sources are groundwater, potable scheme water, surface water, and high quality recycled water from the Kwinana Water Reclamation Plant (KWRP). Industrial effluents in KIA are either treated by the Kwinana Waste Water Treatment Plant (WWTP) or the respective industrial operations prior to being disposed of in Cockburn Sound and SDOOL. The available SDOOL secondary treated effluent source is estimated at approx. 29.6 GL/yr, with potential duplication in 2015 (Burns and Roe Worley 2006).

Recycled water could potentially be used for industrial processes where the risk to the general public is less because they may not be in direct contact with the effluent. However, there are still risks to be considered with those that are working within the industry and there should be procedures in place to ensure that the risks are minimised. In order to determine whether the recycled water can be reused, the risk assessment and also legal requirement need to be established. The risk assessment for the Kwinana Industrial Area has already been established by GHD (GHD 2008). The GHD risk assessment methodology is largely built on the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks, Phase 1 and the Draft Australian Guidelines for Water Recycling Stormwater Harvesting and Reuse. This document also identified a decision tree for industrial use of recycled water.

The general governance of water is separated into pricing and regulation, planning and management, markets, supply and services, drinking water management, recycled water management and environmental health management. In order to reuse the recycled water in industry, the two major sectors to investigate would be the recycled water and environmental health management. The governance for recycled water and environmental health management for Australia is usually overseen by the relevant health and environment departments . Each State/Territory would then have additional requirements depending on the scope of works proposed (for example industrial or residential).

In the different States and Territories, the relevant Departments of Health are involved with recycled water management. Their role is primarily to consider the health implications of effluent reuse, to set quality standards and regulate water supply to ensure that public and workers' health risks are reduced. The Departments of Health are not involved with recycled water management in Queensland (managed by the Department of Natural Resources and Water), NSW (managed by the Department of Environment and Climate Change, Department of Water and Energy, Local Councils) and Victoria (managed by the Environmental Protection Authority); however, the water management roles of these agencies are similar.

Recycled water use may have an impact on environmental health and as a result it is important to ensure that the risks are reduced. All the States and Territories have an Environmental Department who ensure that the relevant legislative and policy requirements are met, and whether the proposed actions could potentially have an effect on the environment. Within industry, the alternative sources of water may be sourced easily; however the legislation may not always be consistent with the National Water Initiative policies (ACIL Tasman 2007)

Transfield Services have identified agencies and approvals requirements for capital works in the water industry. The main areas of concern are human health, potential environmental risk, sites of international importance, areas of indigenous importance and building/infrastructure access or approvals. Based on the legislative framework in Western Australia, as long as the industry meets the requirements set by the different agencies, recycled water use will be approved. Improvements in water planning processes and tailored water management for specific areas will be addressed in the *Water Resources Management Bill* (Department of Water. 2008). This will give water users and managers more clarity as the planning framework will be more robust.

Water licenses can be given out through the *Rights in Water and Irrigation Act 1914 (RIWI Act)*. The Act allows for the development of water plans to guide the management of water resources in regional, sub-regional and local areas. The Department of Water (previously the Water and Rivers Commission) is responsible for managing and administering water access entitlements and allocations in WA. Under the RIWI Act, licences can be allocated if water is being removed from a proclaimed water source and licences can be allocated or approval given to construct and operate works to access water. There does not seem to be a specific provision for exchange of treated recycled water (ACIL Tasman 2007).

At present the third party access to water and wastewater related infrastructure can be obtained under the provisions of the Trade Practices Act 1974, a very time consuming and costly process which discourages market entry. The State Inquiry on Competition in the Water and Wastewater Services Sector (2008) recommends a simple State-based third party access regime to be introduced for easier access. In addition one of the recommendations of the Inquiry into Pricing of Recycled Water in WA (2009) provides for allowing third party access to the wastewater network for the purpose of providing recycled water.

In regard to recycled water, the Economic Regulation Authority recommended that a set of pricing principles should be introduced and reviewed periodically by an independent regulatory review. They also acknowledged that "the pricing principles need to be introduced in the water agencies charges bylaws" (ERA 2009). These price principles reflect the prices that would emerge under a competitive market and are to be established under a third party access regime.

Generally in Australia the current price of recycled water is lower than the price for scheme water supply and is determined on a project-by-project basis (MacDonald 2004). In Western Australia, the price of providing water and wastewater services is set to rise in the foreseeable future, despite the expectations that increased competition will deliver better economic efficiency. The price of recycled water is expected to rise in line with increasing prices of scheme water, or where substantial infrastructure projects are required to expand recycled water supply. In addition, the demand for recycled water is likely to increase over time, if consumer acceptance of recycled water improves, the price of scheme water increases and wastewater disposal costs increase in line with associated externality charges (MacDonald and Dyack 2004). Recycled water pricing could also be affected by the quality and efficiency of current and future treatment technologies.

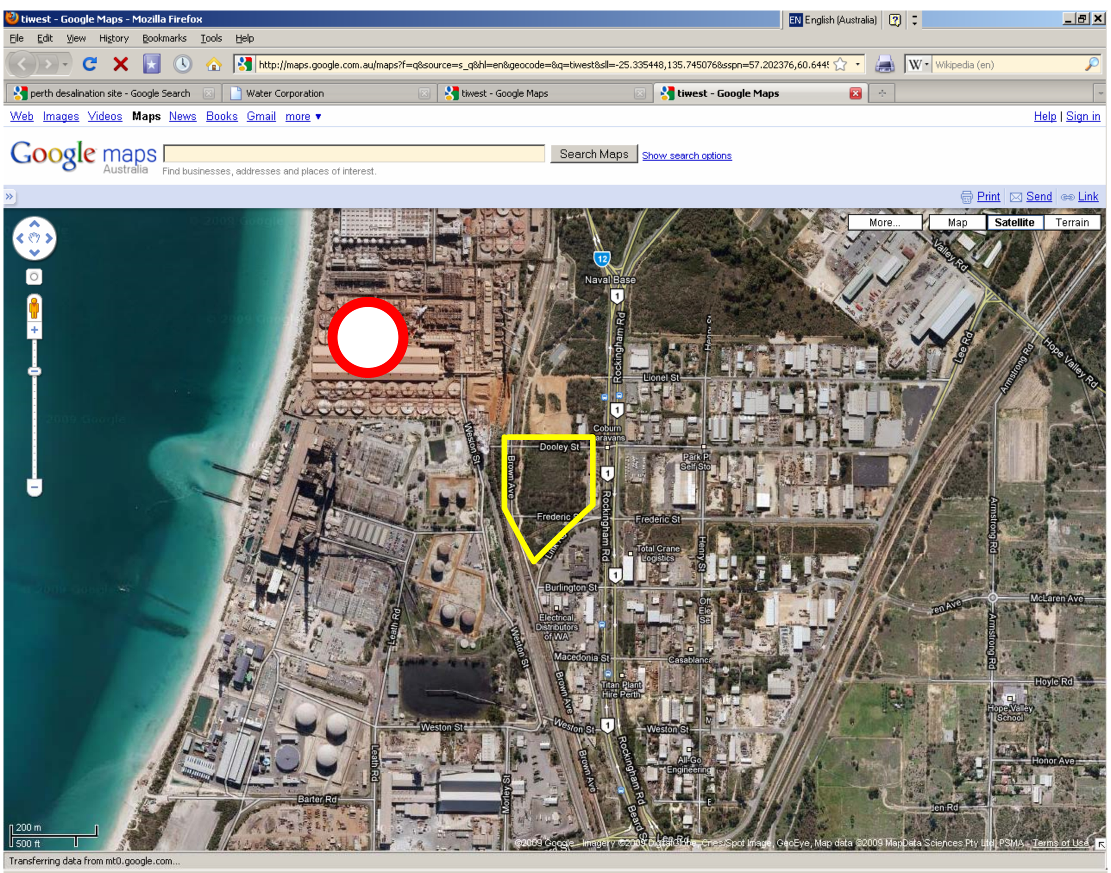
International experience shows that in the majority of documented case studies the price of water supply and treatment increases with the deregulation of water services given local policy, contractual and supply and demand circumstances. Growing population and specific climate conditions in Western Australia is expected to put further pressure on service provider/s to build new infrastructure and explore alternative water sourcing. Furthermore, securing additional water sources through the utilisation of recycled waste waters not only assists in the risk management of long term water requirements but provides an important opportunity for industry to ensure sustainable water consumption in the future.

4. 5 GL Demonstration Plant - Preliminary Identification of Suitable Sites and Heat Sources

As a result of the identification of two possible sites and the preferred desalination technology by project 126, stage 1a, a very basic option identification study was carried out for a demonstration desalination plant (5GL). This opportunity was investigated as part of a funding proposal to the DEWHA Water for the Future Plan, but the proposal later abandoned as KIC and eco-efficiency committee have acknowledged the insufficient lead time needed to organise successful proposal.

The demonstration plant with expected capacity of up to 5GL of water pa would employ a proven multi effect evaporative desalination (MEE) technology, and could preferably utilise the sea water used for cooling as an input. The study has identified two potential sites for the location of the demonstration plant.:

1. The first option features a demonstration desalination plant utilising waste heat from one of the Alcoa's calciners (red circle, on Figure below), located on a land nearby owned by Alcoa, see Figure below. The demonstration plant could utilise the sea water used for cooling at the Kwinana Power Station as an input. The waste heat recovery unit at Alcoa could potentially generate additional 1GL (estimated) of water from steam condensation. The initial assumption for ideal location within the boundary of the existing desalination plant was abandoned as it has become clear that was not feasible due to geographical, process and regulatory limitations.



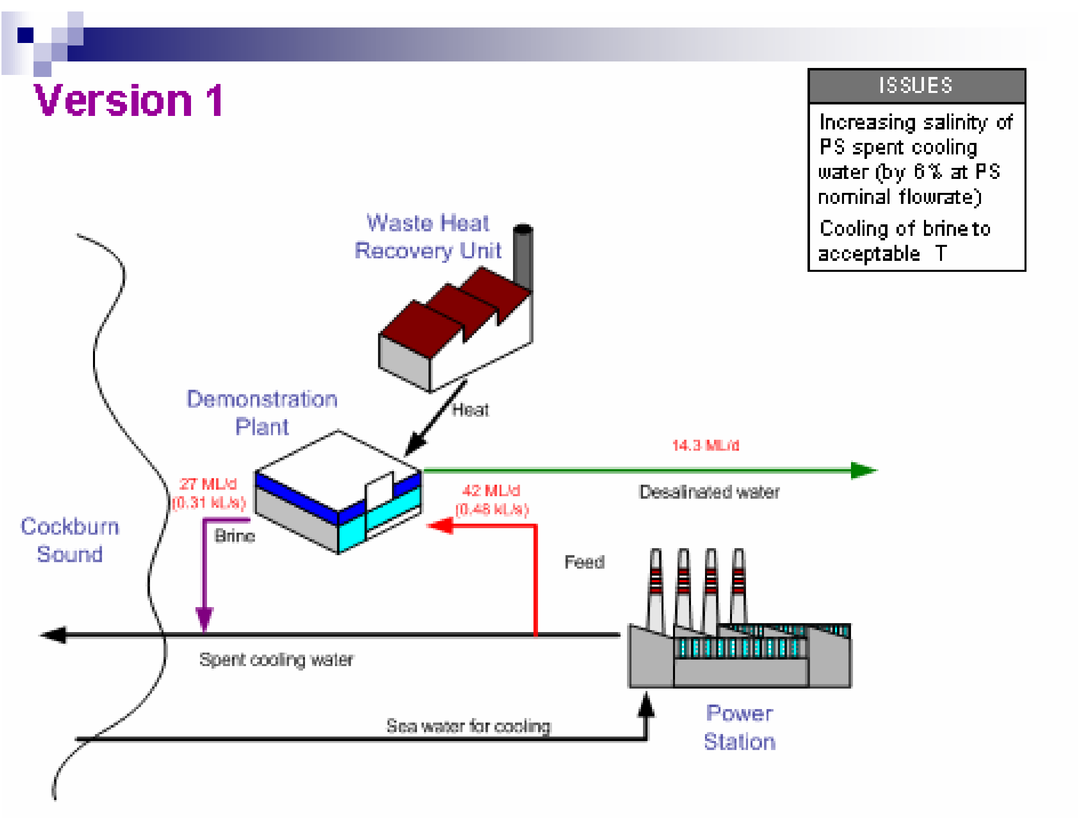
The potential partners for this option were identified as Alcoa, Kwinana Power Station, Water Corporation and also was anticipated that the project would attract a third party company, most likely in the water business, to take stake in the project.

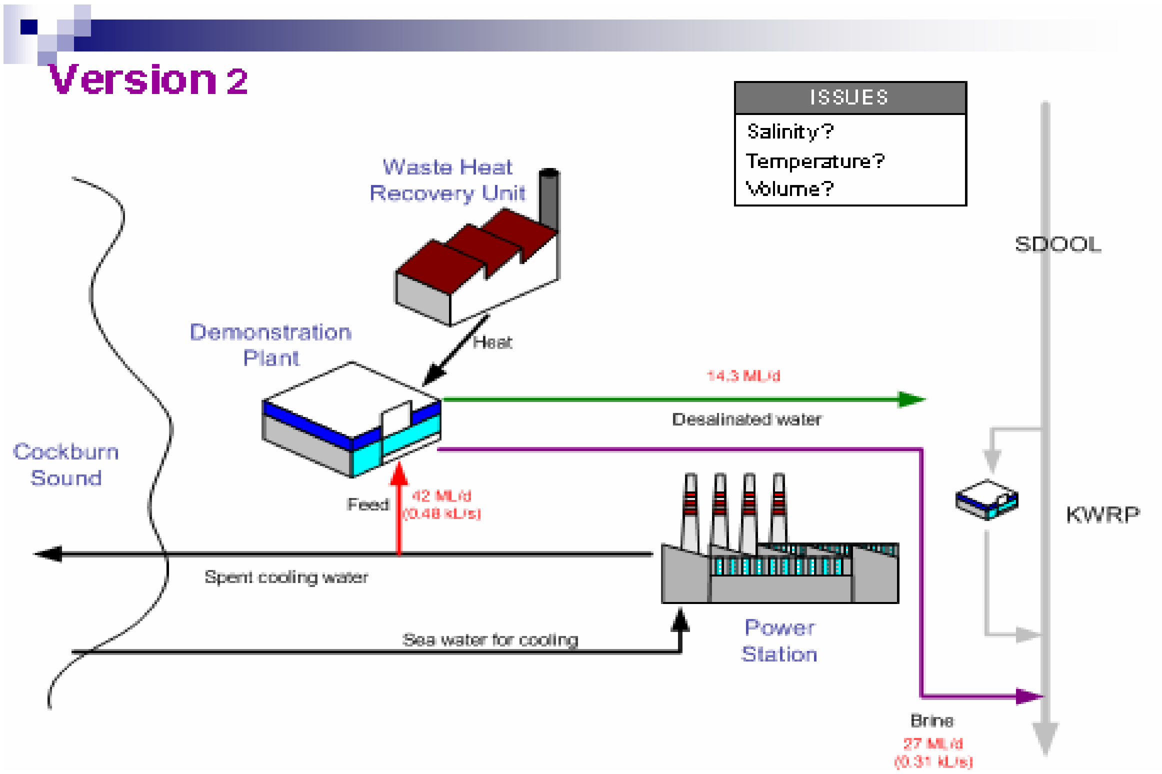
Bases on the preliminary assessment for Multi effect evaporative desalination (MEE) the capital expenditure was estimated to be $900-2000 USD per KL/day, while the operating expenses were estimated to be $0.45-1.17 USD per KL. The recovery rate was taken to be 35%.

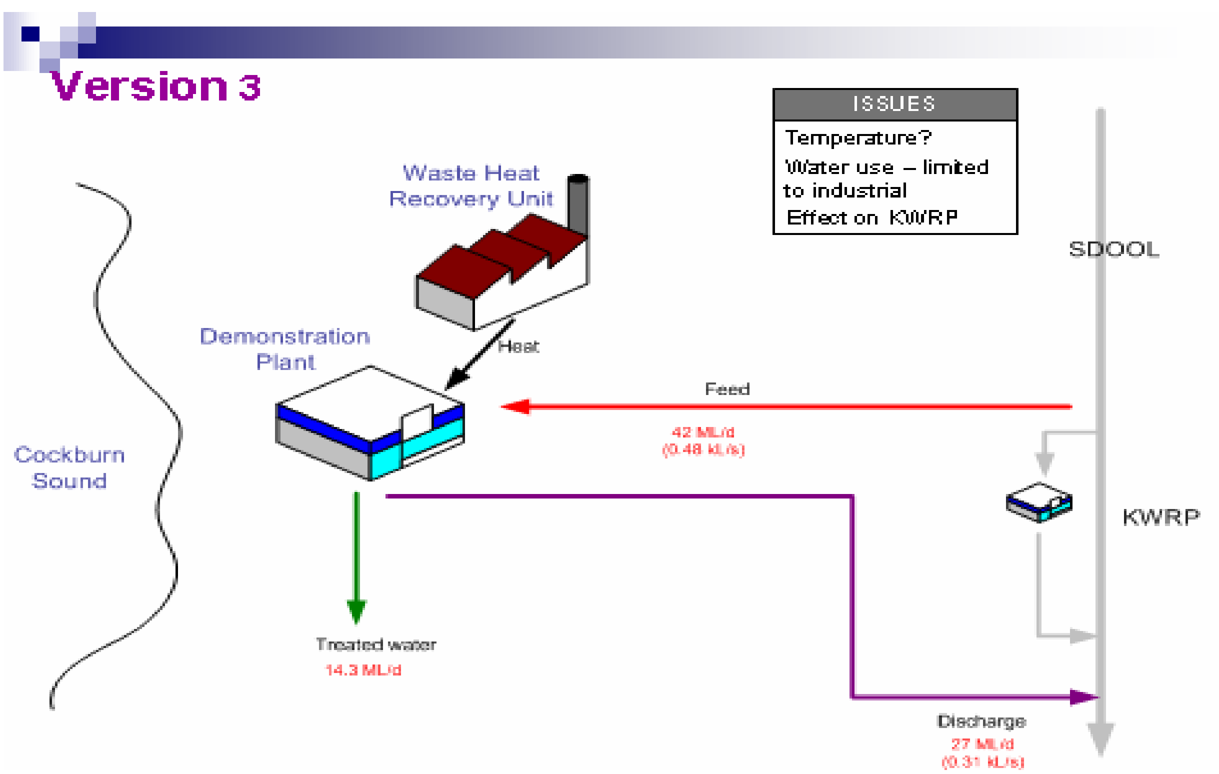
The feed and discharge to suit a 5GL plant were estimated as follows:

- Feed
    - Flowrate – 42 ML/day
    - TDS – 35,000 mg/L
    - Temperature – up to 6°C above ambient T
- Discharge
    - Flowrate – 27 ML/day
    - TDS – 60-65,000 mg/l, depending on number of effects
    - Temperature – 45-50°C, depending on number of effects

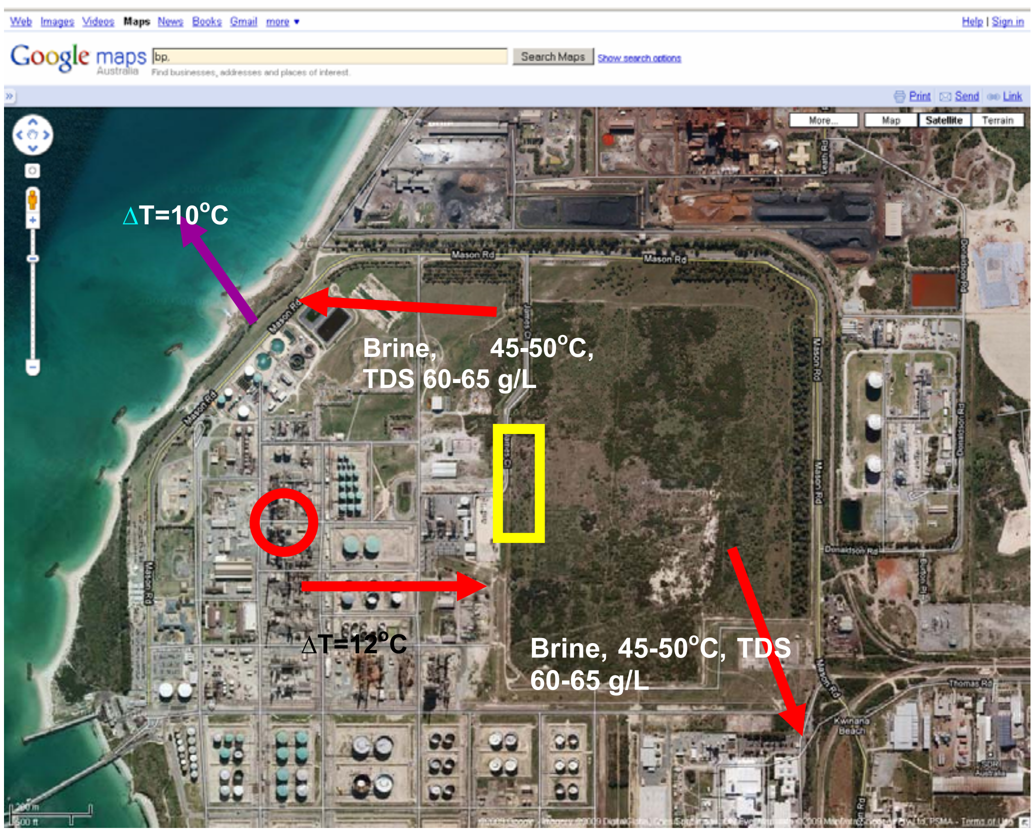
Three alternative versions for the feed and discharge were identified and shown below. Common issues identified were, the temperature and the salinity of the discharge as well as the volume in case of discharge to SDOOL, as well as the effect on the KWRP operation.




Version 2
ISSUES
Salinity?
Temperature?
Volume?
Waste Heat
Recovery Unit
SDOOL
Demonstration
Plant
Heat
14.3 ML/d
Desalinated water
Cockburn
Sound
KWRP
Feed
42 ML/d
(0.48 kL/s)
Spent cooling water
Sea water for cooling
Power
Station
Brine
27 ML/d
(0.31 kL/s)


Version 3
ISSUES
Temperature?
Water use – limited
to industrial
Effect on KWRP
Waste Heat
Recovery Unit
SDOOL
Demonstration
Plant
Heat
Feed
42 ML/d
(0.48 kL/s)
Cockburn
Sound
KWRP
Treated water
14.3 ML/d
Discharge
27 ML/d
(0.31 kL/s)

2. The second option features potential use of land , known as PICL (Petrochemical Industries Company Ltd), located east of BP refinery. The potential heat source (Regen 2) has is similar heat parameters as Alcoa's calciner, but there are limitation it terms of accessibility, i.e. it is accessible only during maintenance periods, which are two years apart. Feed sea water is 12°C above ambient and can be accessed close to the eastern fence, Discharge can be directed to sea or SDOOL line, similar to the first option. Another issue identified was the potential of oily leak.



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5. KIA SUSTAINABILITY INDICATORS - DATA SOURCES AND COLLECTION METHODS

5.1. Introduction

Performance indicators have been used for years by businesses and governments to measure their performance and make informed decisions. Sustainability indicators have been used in the last decade to demonstrate business' commitment to Sustainable Development. These indicators are generally specific to the individual facility operations or corporations and are often presented in a vast variety of manners and measurement units.

Development and implementation of Regional synergies a relatively new field and performance measurement has been inconsistent. The use of performance indicators has been limited, especially with respect to measuring the benefits for a group of businesses, or a specific geographical area. The Norwegian Institute of Science and Technology Industrial Ecology Programme looked at the application of eco-efficiency indicators to "recycling systems" by adapting the World Business Council for Sustainable development eco-efficiency measurement framework. They draw attention to the added complexities created by groups of businesses, and the importance of setting borders (Eik, Steinmo et al. 2002). A study undertaken by Eco-Industrial Solutions for Industry Canada has investigated a framework for Sustainable Industries Performance indicators that allows benchmarking and comparison of financial, energy, materials, water, land use & transportation, and corporate & municipal governance performance, among individual companies as well as across industrial areas / parks (Casavant and LeBreton 2005) . The Institute of Applied Ecology at the Chinese Academy of Science examined the applicability and feasibility of an indicator system and then analysed the benefits and challenges concluding that the indicators do not address the essence of the eco-industrial park (Yong, Pan et al. 2009).

Neither of these studies has resulted in a practical, tested set of performance indicators.

5.2. KIA Sustainability Matrix

The GRI framework (GRI 2000) was used as a basis for the development of the initial set of KIA sustainability indicators. This initial list of possible indicators has been discussed with different stakeholder groups and generated a preliminary set of primary and secondary performance indicators of the KIC Sustainability Management Matrix (Table 1). Seven priority areas were selected, namely energy, water, by-products, economy, environment, community, and workforce. Through the KIC Eco-Efficiency Committee, the matrix has been populated with relevant primary and secondary performance indicators.

Principally, the KIA stakeholders agreed that the Sustainability Management Matrix should contain a relatively small number of key indicators, but still large enough to provide a holistic overview of the sustainability performance of the KIA. The current matrix contains 21 primary performance indicators and 26 secondary performance indicators. This has been perceived as a number still manageable and useful for internal and external communications. Another important selection criteria for the performance indicators was that they could possibly provide a basis for benchmarking KIA with other (inter)national industrial areas (Van Beers 2008).

Table 5-1: Kwinana Industrial Area Sustainability matrix

Target	Indicator	Unit
ENERGY		
Primary Performance Indicators		
Carbon neutral KIA	Net GHG emissions (CO2 -eq) per economic output	ktonnes CO2-eq/$Bn KIA GDP
World benchmark in energy conservation	Total energy consumption per economic output	PJ/$Bn KIA GDP
Secondary Performance Indicators		
	CO_2 emissions	kt CO_2
	GHG emissions	kt CO_2 -eq
	GHG emissions offset	kt CO_2 -eq
	Total energy use	PJ
	Utility synergies (energy)	TJ
WATER		
Primary Performance Indicators		
Zero process use scheme water	Total water use per economic output	GL/ $Bn KIA GDP
World benchmark in water conservation	Fraction scheme water in total water use	%
	Fraction of recycled water in total water use	%
Secondary Performance Indicators		
	Total water use	GL
	Ground water use	GL
	Surface water (total)	GL
	Surface water (low quality)	GL
	Scheme water use	GL
	Off-site water recycling (synergies)	GL
BY-PRODUCTS		
Primary Performance Indicators		
World benchmark in re-used by-products	Reused by-products as fraction of total process residues	%
	Number of by-product synergies	#
Secondary Performance Indicators		
	Process residues	kt
	Reused by-products	kt
ECONOMY		
Primary Performance Indicators		
Recognised as the premier industrial estate in Australia	Contribution KIA GDP to WA GSP	%
Secondary Performance Indicators		
	Total sales (KIA GDP contribution)	$M
	Direct and indirect wages and salaries	$M
	Purchase of goods	$M
	Purchase of imported goods (international and national)	$M
	Total number of material interactions	#
ENVIRONMENT		
Primary Performance Indicators		
World benchmark	Air emissions per economic output	
	SO_2	tonnes / $Bn KIA GDP
	NOx	tonnes / $Bn KIA GDP

Target	Indicator	Unit
	PM10	tonnes / $Bn KIA GDP
	Cockburn Sound quality measures	Below guidelines in selected criteria
	Physical/chemical	
	Direct biological	
	Toxicants	
	Number of incidents of non-compliance with noise regulations in KIA	#
Secondary Performance Indicators		
	Air emissions	
	SO_2	tonnes
	NOx	tonnes
	PM10	tonnes
COMMUNITY		
Primary Performance Indicators		
Welcome neighbour	Contributions to community program per economic output	$k / $Bn KIA GDP
	Fraction community that believes industry has positive impact on community wellbeing	%
Secondary Performance Indicators		
	Contributions to community programs	k$
WORKFORCE		
Primary Performance Indicators		
Sustainable workforce	Number of direct and indirect employees per economic output	employees / $Bn KIA GDP
	Fraction apprentice / traineeships of total direct workforce	%
	Fraction employees living locally	%
	Lost Time Injury Frequency Rate (LTIFR)	No of lost time injuries per million hours worked
Secondary Performance Indicators		
	Employees (direct)	#
	Employees (indirect)	#
	Apprentice / traineeships (total)	#
	Apprentice / traineeships (female)	#

Explanation of the above indicators is offered in Appendix 1.

5.3. Information Needs and Issues

Shown in Table 5-2 is a list of information needed to calculate the KIA sustainability indicators presented. Potential data sources have been noted together with the difficulties for data collection that have become apparent.

Table 5-2: Potential data sources for KIA Sustainability Matrix

Category	Parameter	Data Sources and Issues

Category	Parameter	Data Sources and Issues
GHG/Energy	CO2 emissions	GHG emissions may potentially be obtained from National Greenhouse and Energy Reporting (NREG) initiative. Its first year of reporting is 2009. It is unclear whether the data will be aggregated or shown by individual facility. Another difficulty is that not all of the KIC member companies are going to be obligated to report since there is a moving facility threshold that will exclude facilities with less that 25kt emissions or 100TJ energy use. See discussion below table. Suggested method of data collection – individual businesses.
GHG/Energy	GHG emissions	
GHG/Energy	GHG emissions offset	
Energy	Total energy consumption	This type of data may be found in environmental or sustainability reports. There are a number of complexities that would render this approach unfeasible. Firstly is that not all of the KIC member companies publish public reports, and secondly the data for the parameters in this group shows inconsistency in reporting standards, if any data exists. Generally reporting tends to focus mainly on presenting improvements and is often showed as percentages reduction or tonnes/kL reduction. Many of the companies that publish such reports do report total corporate quantities rather than provide details for single facilities. Suggested method for data collection – individual companies. Companies that do not produce annual reports may be able to obtain this sort of data from utility bills, internal monitoring and reporting, purchasing records, mass and energy balances.
Energy	Non-renewable energy use	
Energy	Renewable energy use	
Energy	Recovered energy use	
Water	Scheme water use	
Water	Ground water use	
Water	Surface water	
Water	Surface water (low quality)	
Water	Recycled water	
Water	Off-site water recycling (synergies)	
Water	Total water use (excl sea water)	
By-Products	Process residues	
By-Products	Reused by-products	
By-Products	Number by-product synergies	At present there are 32 by-product synergies and 15 utility synergies. Approaching the individual companies is the only suggested approach, unless there is an external annual update.
Economy	GSP WA	ABS: Australian National State accounts, publication 5222.0
Economy	KIA GDP (Total output of KIA industries)	See discussion below table
Economy	Annual industry output KIA (direct sales)	This type of data may be found in annual financial reports. Because of the issues described above the suggested data collection method id directly from individual companies.
Economy	Total wages and salaries (direct and indirect)	
Economy	Capital investment	
Economy	Purchase of goods	
Economy	Purchase of imported goods (international and national)	
Economy	Total number of material interactions	Data on this parameter can be fount in the KIA impact assessments for 2000 and 2005. As the process for collecting this type of data may be too elaborate to be carried out on a yearly basis, it is suggested to use the impact assessment as source.
Environment	SO2 emissions	There are two possible methods for collecting this particulate type of data: (1) approaching individual

Category	Parameter	Data Sources and Issues
Environment	NOx emissions	companies, that report to NPI and aggregating their emissions, or (2) using the NPI data for the Kwinana airshed. The latter figures might contain some large emitters that are not members of KIC. Suggested method – individual companies.
Environment	PM10 emissions	
Environment	Cockburn Sound: physical/chemical measures	Cockburn Sound Management Council web site – yearly report cards.
Environment	CS: direct biological measures	
Environment	CS: Toxicants in water and sediments	
Environment	Number of incidents of non-compliance with noise regulations in KIA	Individual companies
Community	Contributions to community programs	Individual companies
Community	Fraction community that believes industry has positive impact on community wellbeing	Community satisfaction survey – KIC
Workforce	Total employees (direct and indirect)	Data can be obtained either from Workforce &Education committee representatives, KIC, or directly from individual companies.
Workforce	Employees (direct)	
Workforce	Employees living locally	
Workforce	Employees > age 55	
Workforce	Female employees	
Workforce	Apprentice/traineeships - males	
Workforce	Apprentice/traineeships - females	
Workforce	Apprentice/traineeships - total	
Workforce	Lost Time Injury Frequency Rate	Individual companies

The KIA Sustainability Matrix is the first of its kind worldwide and there is a need to establish a consistent and transparent method of data collection and management. The indicators should be measurable, data must be available, and they also should allow for comparison. There are a number of rules and provisions that need to be set, as follows:

- To ensure the integrity of the indicators there need to be a set list of companies whose data is used. The options are: KIC full members, KIC all members, or another group of companies, such as mix of KIC member and no-members. It is envisaged that the KIC member list is not static and may vary with time; therefore it is proposed that data is collected from *all* KIC members for the corresponding year regardless of their number and size, and this data is then be used for the calculation of the sustainability indicators.
- The majority of the parameters needed to calculate the sustainability indicators are obtained by summing the data from individual companies. A simple data collection sheet has been provided to KIC to assist them with the data collection process. The sheet is Excel based and it can be distributed either electronically or as a hard copy.

- A simple tool has been provided to KIC to assist with the data management, as well as with monitoring trends and reporting on the sustainability indicators.
- Given the set of the companies providing the data (KIC members), most of the indicators will be consistent over the years with the exception of these:
    1. *CO2 emissions, GHG emissions and GHG offset* – larger emitters will have no difficulties to provide the GHG emission estimates as they would be required to report these as of 2009. However facilities with less than 25kt emission or less than 100 TJ of energy use (there are also thresholds for corporate groups) will not be able to provide accurate estimates on their emissions, unless they have some internal monitoring and reporting mechanism. It is suggested that only data from the larger emitters is used and the cut-off threshold is clearly stated. That will be beneficial when other industrial area or region wishes to compare their performance to KIA's.
    2. *KIA GDP (Total output of KIA industries)* – KIA GDP or the Total output of KIA industries need to be formulated in a way that is easy to understand and useful for benchmarking and comparative purposes. It is understood that the original intention was to use the total economic impact from the KIA Impact Assessment studies, carried out for 2000 and 2005. However, the values stated in these assessments contain some estimated parts, as well as the inclusion of companies that are not KIC members. Unless the methodology of calculating that Total KIA output is clearly defined that may render most of the important indicators useless for benchmarking purposes. As this parameter appears as a common denominator in 8 out of the 21 primary performance indicators it is proposed that this common denominator is replaced with the *Annual economic output* (as the sum of the incomes generated by the production of goods and services by the KIC members) instead.

5.4. Appendix 1 - Definitions

Terminology	Definition / explanation
1) Energy	
Net GHG emissions	Total GHG emissions less offsets
GHG emissions	Includes: carbon dioxide (CO_2), methane (CH4), nitrous oxide (N_2O), hydrofluorcarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF6).
GHG emissions offset	Reductions in GHG emissions achieved by industries through various means (e.g. energy efficiency, sequestration, use of renewable energy, emissions trading).
Non-renewable energy	Energy which comes from a source which can only be used once and cannot be replaced once it is used up, eg energy from burning fossil fuels.
Renewable energy	Energy derived from sources that do not deplete natural resources. Examples include solar, wind, and geothermal energy.
2) Water	
Total water use	Includes: scheme water, ground (bore) water, surface water (site drainage) and off-site water recycling.
Fresh water	Any water that can be used as drinking water without significant treatment
Off-site water recycling	Includes: water reuse between industries, Kwinana Water Reclamation Plant, direct reuse of effluent from the Kwinana and Woodman Point wastewater treatment plants and Sepia Depression Ocean Outfall Landline (SDOOL).
Surface water (fresh)	From flowing water bodies, such as rivers, creeks
Surface water (low quality)	Standing water on the industrial site, e.g. dams
3) By-Products	
Process residues	Solid and liquid residues (not part of final product) generated by industrial operations. Excludes: water and air emissions.
Reused by-products	Residues from industrial operations which are reused in any way (e.g. internally, other company, supplied directly to market).
By-product synergy	The (re-)use of previously disposed industry residues (as solid, liquid, or gas) from one facility by another facility to produce a valuable by-product. Excludes: water and energy exchanges between industries.
Utility synergy	The shared use of energy and water utility infrastructure, including water and energy exchanges between industries (e.g. water recovery and cogeneration).
Material interaction	Use of products or by-products by other industries as raw materials and, if appropriately co-located, such material interaction may be facilitated through dedicated conveying technology such as pipelines or belt conveyors.
4) Economy	
GDP	Gross Domestic Product (Australia).
GSP	Gross State Product (Western Australia).
5) Environment	
PM10	PM10 is particulate matter 10 micrometers or less in diameter.
Physical and chemical measures (Cockburn Sound)	Includes environmental quality indicators for Chlorophyll ‘a’, light attenuation, dissolved oxygen, temperature, salinity, pH. As monitored and reported by the Cockburn Sound Management Council.
Direct biological measures (Cockburn Sound)	Includes environmental quality indicators for phytoplankton biomass (Chlorophyll ‘a’) and seagrass (shoot density, depth limits). As monitored and reported by the Cockburn Sound Management Council.
Toxicants (Cockburn Sound)	*Toxicants in water:* includes environmental quality indicators for metals and metalloids and non-metallic inorganics (organics, pesticides, herbicides and fungicides, surfactants, hydrocarbons, and miscellaneous/others). As monitored and reported by the Cockburn Sound Management Council. *Toxicants in sediments:* includes environmental indicators for organometallics (e.g. TBT), metals and metalloids, and organics. As monitored and reported by the Cockburn Sound Management Council.
6) Community	

Terminology	Definition / explanation
Community	Residents of Kwinana, Rockingham and Cockburn Sound?
7) Workforce	
Employees living locally	Employees living within 15 km distance from their main workplace
Lost Time Injury Frequency Rate (LTIFR)	Number of lost time injuries per million hours worked.

5.5. Appendix 2 - Data Collection

	GHG Emissions	QTY	Unit*	Comments
1	CO_2 emissions			
2	GHG emissions			
3	GHG emissions offset			

* Please specify unit: CO_2-eq tonnes, CO_2-eq ktonns, CO_2-eq Mtonnes

	Emissions	QTY	Unit*	Comments
25	SO_2 emissions			
26	NO_x emissions			
27	PM_{10} emissions			

* Please specify unit: tonnes, ktonnes, Mtonnes

	Energy	QTY	Unit*	Comments
4	Total energy consumption			
5	Non-renewable energy use			
6	Renewable energy use			
7	Recovered energy use			

* Please specify unit, for example: kWh, MWh, kJ, GJ, TJ
Non-renewable energy includes LNG, LPG, Diesel, Petrol, Coal, and any other type (if applicable)

	Water	QTY	Unit*	Comments
8	Scheme water use			
9	Ground water use			
10	Surface water			
11	Surface water (low quality)			
12	Recycled water (on-site)			
13	Off-site water recycling (synergies)			
14	Total water use (excl sea water)			

* Please specify unit, for example: kL, ML, GL

	By-Products	QTY	Unit*	Comments
15	Process residues			
16	Reused by-products			

* Please specify unit: tonnes, ktonnes, Mtonnes

	Economy	Amount	Unit*	Comments
19	Annual industry output KIA (direct sales)			
20	Total wages and salaries (direct and indirect)			
21	Capital investment			
22	Purchase of goods			
23	Purchase of imported goods (international and			

* Please specify unit:$, M$, etc.

	Workforce	QTY	Comments
34	Total employees (direct and indirect)		
35	Employees (direct)		
36	Employees living locally		
37	Employees > age 55		

38	Female employees		
39	Apprentice/traineeships - males		
40	Apprentice/traineeships - females		
41	Apprentice/traineeships - total		
42	Lost Time Injury Frequency Rate*		

*Please use "Claims per million hours worked" for LTIFR

	Other	
17	How many by-products and utility synergies your company is involved in?	
32	Number of incidents of non-compliance with noise regulations	
33	Contributions to community programs ($)	

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