Cleaner production and eco-efficiency initiatives in Western Australia 1996–2004

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Abstract

This paper summarises developments in the promotion and implementation of cleaner production (CP) and eco-efficiency (EE) in Western Australia (WA), in four stages: groundwork (1996–1999), experimentation (1999–2002), roll out (2002–2004) and reorientation (2004 onward). The remoteness of WA and the dominance of the minerals, energy and agribusiness industries, contributed to the late interest in CP and relatively slow start. Pioneers in government, industry and academia started to come together in 1998–1999. Subsequent clarification of concepts and design of programs resulted in a two-pronged strategy to create both a supply and demand for CP services. This enabled a rapid increase in interest in CP, which started to level in 2004. Although this is partially due to external circumstances, it also appears that the limits of current CP and EE theory and practice have been reached. These limits appear to be at least two fold. First, current policies and program designs appear not yet able to achieve a step-increase in the number of businesses involved in CP. Insights from innovation and social marketing theory and practice are now being incorporated in the design and delivery of the next generation of CP programs. Second, it appears that mainstream CP tools are insufficiently catered to the technological and organisational complexity of many industries. Greater engineering and management depth in CP tools might be required to mainstream CP in routine process design, continuous improvement and change management practices.

Keywords: Cleaner production (CP); Eco-efficiency (EE); Western Australia (WA)

1. Introduction

The completion of Australia’s National Cleaner Production (CP) Demonstration Project in 1995 [1,2], sparked the development of a national framework for CP implementation. Western Australia (WA) remained a relative outsider to this development for at least two reasons. First, CP did not strike easy accord with the dominant mining, minerals, energy and agricultural industries, given its roots in the manufacturing industry (e.g. [3–9]). Second, the then prevailing antagonism between business and environmental regulators prevented effective stakeholder input. When the National Framework was finally launched in 1998 [10] there was no sign of CP uptake in WA. A remarkable turnaround has been achieved since then, which is being discussed here.

This historic account of key CP developments starts in 1996 and is roughly divided into four periods, here referred to as groundwork (Section 3), experimentation (Section 4), roll out (Section 5), and reorientation (Section 6). In hindsight these are the logical benchmarks to discuss WA’s CP journey. However these were not laid out in advance, nor were the transitions instant and complete in time. Section 2 provides essential contextual information on WA, and Section 7 reflects on the overall achievements and challenges ahead.

2. Context

Western Australia (WA) is the largest sub-national state in the world, with a land mass of 2.5 million square kilometres (a third of the Australian continent) and a population of less then
2 million (~10% of Australia’s total), which is highly concentrated in the greater Perth metropolitan area (~75% of WA’s population) [11]. WA is isolated from the rest of Australia by deserts and highly arid land, which over millions of years has led to the formation of unique and varied landscapes and seascapes supporting a significant biodiversity of flora and fauna. WA generates about 12% of Australia’s total factor income and about 25% of Australia’s export earnings [12]. The economy relies heavily on three sectors (in 2001/2002) [11]:

1. Energy: mainly offshore gas (18,560 million m3) and oil (19,756 megalitres) and some coal in the South West for domestic use
2. Minerals and metals: iron ore (180 million tonnes) and diamonds (30 million carats) in the far north, gold (185,700 kg) and nickel in the Goldfields and other inland areas, and bauxite and minerals sands on the South West coastal plain
3. Agriculture: traditionally broadacre wheat and sheep industry, but more recently diversified into horticulture, viticulture and aquaculture

Despite the fact that significant and diverse CP experience had been built up by the mid-1990s, both nationally [2,5] and internationally (e.g. [4,6–8,13–16]), there was not much evidence that CP could be implemented in these core sectors of the WA economy.

Even though WA had formally committed itself to environmental stretch targets, for example through the State’s Recycling Blueprint [17], the environmental policy practice was throughout the 1990s driven by the command and control paradigm, with deep-rooted distrust between industry, government and the community. Communication on industry’s environmental initiatives was scarce, with perhaps the exception being post mining ecosystem reconstruction (‘mine-site rehabilitation’ [18,19]). Environmental impacts were particularly visible in the Swan Canning River System, in the heart of the Perth metropolitan area, due to spills and algae blooms.

The hazardous waste fire at Waste Control in the Eastern Suburbs of Perth on 15 February 2001 tragically illustrated the failure of the State’s environmental policies [20]. By coincidence this happened less then a week after the Labour Party won Government in WA with the help of the green, anti-logging, vote. This led to sweeping reforms in waste and environmental management and policy and their implementation and enforcement, with a renewed strategic commitment to zero waste [21–23].

The State Government also developed over a two-year consultative process, its State Sustainability Strategy [24,25]—the first of its kind in Australia—which is now being implemented with the assistance of a State Sustainability Roundtable (a high level expert advisory body to the Premier).

A similar strategic sustainability planning process took place in several of the leading corporations, in particular those in the minerals and metals industries that participated in the global Mining, Minerals and Sustainable Development (MMSD) Project [26,27].


The State Recycling Blueprint [17], released in 1993, was a report on the state of recycling in WA. Its underlying principle was to identify the most practical and appropriate waste minimisation and recycling strategies to half landfiling by 2000. Despite its focus on waste diversion from landfill, the Blueprint did put industrial waste minimisation on the agenda. Of particular significance was the recommendation for a system of landfill levies to fund waste minimisation initiatives. The landfill levy came into effect on 1 July 1998 (at A$1/tonne for inert waste and A$3/tonne for putrescible waste), and the Waste Management and Recycling Fund (WM&RF) was created to provide grants for waste minimisation initiatives. The Fund was earmarked to serve five strategic objectives, one being CP. The Blueprint also recommended to draft an industrial waste minimisation policy. A draft was released for public consultation in 1998 [28], but it was never finalised, nor formally acted upon.

Simultaneously government initiated an industrial environmental risk assessment with a focus on protection of water bodies, i.e. the Swan River and groundwater. It covered 522 light industries during 1997–1999, and found significant and widespread deficiencies in chemical storage, waste management, waste and storm water management, emergency preparedness and general environmental awareness [29]. It recommended to “promote best management practices in pollution prevention as the preferred approach to managing environmental risk”. Even though the report did not specifically mention CP, the overall intent of the recommendations was to foster the uptake of preventive environmental strategies by light industries, i.e. CP.

These government initiatives came however only to fruition through commitment and leadership from the business sector. CSBP, the State’s largest fertiliser producer and manufacturer of industrial chemicals, invited in 1996, Prof. Don Huisingh (then associated with Erasmus University of Rotterdam, The Netherlands) to address its leadership conference on CP and lobby the State Government and Curtin University of Technology into a more proactive role in CP. Edmonds Management succeeded in the same period to bring Mr Bjorn Stigson (President of the World Business Council for Sustainable Development (WBCSD)) to WA for a public seminar on EE as the business link to sustainable development.

By 1997, synergies started to develop between these initiatives and by mid-1998, the following had been achieved to kick-start CP:

- CSBP agreed to sponsor Australia’s first full professorial chair in CP at Curtin University of Technology. The author was recruited and commenced at Curtin in February 1999.
- Curtin University of Technology approved the creation of a professional master’s program in CP.1

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1 Given that this paper is focused on the implementation of CP in businesses and other organisations in WA, the development of curricular initiatives in CP is not further addressed here. More information on teaching developments is available on http://www.cs4cs.curtin.edu.au.
• The Waste Management and Recycling Fund was established and provided its first two grants in the CP category. First, a three-year grant for the establishment of a Centre of Excellence in CP (CECP) at Curtin University of Technology. Second, a grant for a feasibility study for an environmental accreditation scheme for small businesses in the motor trade sector.

This stage concluded with an international Eco-Efficiency workshop on 24–25 May 1999, co-presented by CECP and WBCSD. It showcased international best practice to an invited industry, government and community audience, and facilitated local industries to come forward with examples of EE or alike from their own operations [30]. It was a resounding success for two reasons. First, the examples presented by leading local businesses confirmed that CP and EE were doable. Second, participants experienced that they could learn from the approaches adopted by other businesses in other industry sectors. The participants expressed a desire for an ongoing platform for learning-by-sharing, which led to creation of the WA Sustainable Industry Group (WA SIG).


4.1. Clarification of concepts and benefits

Business and government representatives expressed concern that the CP terminology appeared complicated and cluttered. Pollution Prevention for example referred to the division in the WA Department of Environmental Protection in charge of environmental permits. The work of this division would not qualify as Pollution Prevention in the international arena (e.g. [3,31]). Despite the National Cleaner Production Strategy only being formally endorsed in December 1998 [10], the Commonwealth government jumped ship in February 1999 and re-invigorated its CP initiatives under the new umbrella of EE [32], further confusing the meaning of CP.

A pragmatic approach was therefore advocated in WA to view CP and EE as “complimentary concepts, with Eco-Efficiency focusing on the strategic side of business (‘value creation’) and Cleaner Production on the operational side of business (‘production’)” [33]. This allowed continued use of internationally accepted definitions of CP [34] and EE [15,35], while stressing their mutual interrelatedness as well as their connectedness to other preventive environmental management strategies (see Fig. 1). As a result, it became common to promote CP and EE as being concerned with seven EE ‘objectives’ and involving five ‘prevention practices’ (see Table 1).

Upon clarification of the concepts, the challenge remained to identify compelling business examples that would resonate with the WA business community. In doing so, two obstacles were faced. First, the general absence of Australian business examples that demonstrated the whole range of EE objectives and CP practices. The 2001 review of the case studies contained in Australia’s pre-eminent database of then 109 company examples found for example that this collection inadequately covered the full range of CP practices and EE objectives [36]. Second, many regarded the available CP expertise and experience as not applicable to WA, given the lack of specific examples that related to the key sectors of the WA economy (energy, minerals and agribusiness). A considerable effort was therefore devoted to customisation of the generic CP and EE concepts and methods to the oil and gas [37], minerals processing [38,39], agribusiness [40] and coal sectors [41]. With some effort it was then possible to identify excellent examples of CP practices (see Table 2).

In developing CP communications, CECP aimed for consistency in core messages. Inspired by international examples (e.g. [42,43]), three core messages were pursued, that summarise the why, what and how:

1. Why consider cleaner production? Taking care of the environment makes good business sense. This means that CP is a business improvement opportunity, to reduce costs, risks and liabilities, and enhance efficiency, productivity and profitability.
2. What is cleaner production? CP is an opportunity generating strategy, seeking improvements in regards to...
4.2. Strategy and program development

The program and content development by various agencies over the period 1999—2002 led to a two-pronged strategy, best characterised as supply and demand strategies for CP services (see Fig. 2).

- **Supply strategy** is aimed at building operational, technical and managerial capability in businesses to assess and implement CP opportunities through information dissemination, professional development and on-site technical assistance. Some refer to this as marketing. This is however troublesome as marketing works best for gadgets, and less for concepts, like CP. Moreover it leads to the simplification of CP to ‘things everybody can do’. These are however most often not the most beneficial opportunities in any specific business context.

- **Demand strategy** is concerned with influencing the operating environment of businesses to elicit and augment incentives for CP and identify and manage its barriers, through: compliance, conformance and competition.

The continuous application of an integrated preventative environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment [34]

Prevention practices (e.g. [44, 100, 101]:

1. **Good housekeeping**: improve operation, maintenance and management procedures
2. **Input substitution**: use environmentally preferred and ‘fit-for-purpose’ process inputs
3. **Technology modification**: improve the production facility
4. **Product modification**: change product features to reduce its lifecycle environmental impacts
5. **(On Site) Reuse and recycling**: recover and reuse materials, energy and water

Some refer to this as regulation and co-regulation. However, environmental legislation and use of market based instruments and voluntary initiatives are in their own right inadequate to generate genuine business interest. Competition and conformance elements are essential to position CP as a competitive, business improvement strategy, rather than just an environmental necessity of doing business, and thereby generate the strategic interest and leadership that is necessary to let company CP programs flourish.

Promotion of best practices takes place at the intersection of demand and supply. Best practice promotion is supportive of putting CP and EE on the business, government, community and political agendas.

Four key WA programs are focused upon here to illustrate the diversity and synergy within the context of this two-pronged strategy. These include: small business support program (through CECP), ‘learning-by-sharing’ program and WA CP Statement (both through WA SIG) and Green Stamp program (by the Motor Trades Association (MTA) and WA Department of Environmental Protection (DEP)).

4.2.1. Small business support program

The small business support program (offered through CECP) is the prime example in the supply strategy. Over

Table 1

<table>
<thead>
<tr>
<th>Cleaner production</th>
<th>Eco-efficiency</th>
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<tbody>
<tr>
<td>The continuous application of an integrated preventative environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment [34]</td>
<td>The delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life-cycle, to a level at least in line with the Earth’s estimated carrying capacity [35]</td>
</tr>
</tbody>
</table>

1. **Housekeeping**: improve operation, maintenance and management procedures
2. **Input substitution**: use environmentally preferred and ‘fit-for-purpose’ process inputs
3. **Technology modification**: improve the production facility
4. **Product modification**: change product features to reduce its lifecycle environmental impacts
5. **(On Site) Reuse and recycling**: recover and reuse materials, energy and water

The Centre of Excellence in Cleaner Production (CECP) is hosted by Curtin University of Technology and promotes the implementation of CP and EE in particular in small to medium sized enterprises (SMEs), with funding support from the WA Waste Management and Recycling Fund (WM&RF) (http://www.cleanerproduction.curtin.edu.au).

The WA Sustainable Industry Group (WA SIG) operates as a platform of business, public sector, environment, engineering and education professionals, dedicated to business leadership for a clean and competitive WA. The operations of the WA SIG are directed by a Charter and governed by a multi-stakeholder steering committee, while CECP convenes and facilitates the WA SIG. Moreover, WA SIG is a member of the Regional Network of the World Business Council for Sustainable Development (WBCSD) and signatory to the International Declaration on CP administered through the United Nations Environment Programme (UNEP) (http://www.wasig.curtin.edu.au).

Since 1999 DEP has amalgamated with the Waters and Rivers Commission to form the Department of Environment (DoE).
Table 2

<table>
<thead>
<tr>
<th>Company</th>
<th>Sector</th>
<th>CP Initiatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlas Drycleaning [102]</td>
<td>Dry-cleaning</td>
<td>Improved plant lay out, installation of skylights and rationalisation and insulation of steam pipes, reduced gas consumption and air-conditioning load</td>
</tr>
<tr>
<td>BP (Kwinana) Refinery [103]</td>
<td>Oil refinery</td>
<td>Better operating and maintenance procedures, improved condensate and process water recovery and reuse, upgrade of process units and no flaring policy all contributed to water and energy savings</td>
</tr>
<tr>
<td>Iluka Resources [104]</td>
<td>Minerals processing</td>
<td>Installed after burner, instead of wet scrubber, to treat off gases from synthetic rutile kiln, and feed into waste heat recovery boiler to generate electricity, thereby reducing overall energy and water consumption</td>
</tr>
<tr>
<td>Perth Zoo [105]</td>
<td>Zoo, recreational</td>
<td>Passive solar design of buildings, better irrigation and pond management practices, recycling stations, composting of animal wastes</td>
</tr>
<tr>
<td>Solarhart [106]</td>
<td>Metal products (solar hot water systems)</td>
<td>Skylights and better light controls, replacement of compressed air driven tools, better loading and handling provisions for tanks through enamel furnace</td>
</tr>
</tbody>
</table>

4.2.2. Learning-by-Sharing Program

The WA SIG learning-by-sharing program promotes and advances best practices in CP, EE and sustainability-led innovation. Unlike the small business and Green Stamp programs, learning-by-sharing is not specifically directed at predetermined learning outcomes. Instead it provides for organised and facilitated topical networking among professionals working in the business environment and sustainability field. A typical activity involves an overall scene-setting presentation with some three to five case study presentations, followed by a panel discussion. Example topics addressed in 2000–2002 included: benchmarking and reporting of environmental performance, energy efficiency topics and eco-industrial parks. There would be typically a seminar-like event every second month, with additionally some two to three site visits annually, and an annual CP and EE Roundtable (from 2001 onward). Networking is further enhanced through electronic newsletters and the website.

4.2.3. WA CP Statement

The WA CP Statement is the prime example in the demand strategy. Its development was initiated by the request from the Department of Environmental Protection to WA SIG to provide input into its draft industrial waste minimisation strategy [28]. The WA SIG recommended that a collaborative approach be developed instead of a regulatory approach and in 2000 drafted the WA CP Statement as the basis for such collaborative approach. The Statement was initially based on the UNEP International Declaration on CP [49].

The WA CP Statement [50] presents a vision for the greater application of CP and EE for a clean and competitive WA, achieved through collaboration between industry, State and local government, professional and community organisations, and the education sector. It is therefore best seen as a Statement...
of Intent calling on industry, government, business, community and professional stakeholders to consider CP and EE seriously and act accordingly. The explanatory notes to the WA CP Statement [50] provide greater details as to specific roles a number of stakeholders could play in promoting the uptake of CP in WA.

The WA SIG created a register of signatory organisations, which was launched on 24 May 2001. Organisations become a signatory to the WA CP Statement by signing a Memorandum of Understanding (MoU) with WA SIG. The MoU commits the Signatory organisation to support the intent of the Statement and develop and implement an action plan for furthering CP and EE within its own operations and/or among its constituencies. Upon formation of the Signatory register, the WA SIG developed further resources for the WA CP Statement, in particular the Implementation Guidelines [51], which were formally launched at the 2nd WA CP and EE Roundtable in June 2002. By then the signatory register had expanded to 64 signatory organisations.

4.2.4. Green Stamp Program

The Green Stamp Program was initiated in late 1999. Environmental risk audit protocols, environmental guidelines, training and accreditation criteria were developed for mechanical workshops, car body workshops, panel and paint workshops and wrecking yards. Moreover a three-tiered accreditation scheme was established. Level 1 is an awareness level, and does not entitle businesses to use the program logo. Businesses in level 1 must hold all relevant licences and be operating in a manner that meets all legislative requirements. For level 2 accreditation, businesses must achieve level 1 and have implemented a minimum number of possible practices, typically half of the beyond compliance practices available within the subsector. For level 3 accreditation, businesses must have achieved level 2, and have developed and endorsed for implementation an environmental management plan [52].

The Green Stamp program has a strong focus on environmental risks, as reflected in its listed key issues:

- Storage practices associated with chemicals and other hazardous substances;
- Pre-treatment of wastewater from the workshop prior to approved disposal;
- Spill management to prevent pollution of ground and stormwater systems;
- Correct disposal of waste products (preferably to recycling or reuse);
- Air quality management;
- Energy and resource conservation; and
- Development and implementation of environmental management plans [53].

Except for energy and resource conservation, none of these key issues has a particular focus on CP or EE. The first ten businesses were accredited on 27 November 2002, and both MTA and DEP have since promoted accredited workshops, through their websites, newsletters and the media.

The Green Stamp program is an example of a sector specific environmental accreditation scheme, similar to schemes in other sectors, such as the Greensmart Program for the housing industry (by the Housing Industry Association [54] and the Responsible Care Program for the chemicals industry (by the Plastics and Chemicals Industries Association [55]). Its success is conditional on consumers willing to make the extra effort, and possibly pay the extra cost, to get their cars serviced at accredited workshops. The Green Stamp program raises expectations on the environmental performance of its program participants (i.e. conformance pull). Moreover, the availability of the environmental accreditation scheme, and the actual and/or perceived market benefits thereof, are expected to draw more businesses into the program (i.e. competitiveness pull).

The period of intense developments in CP and EE concepts, contents, strategy and programs came to an end around 14 June 2002 at the occasion of the 2nd WA CP and EE Roundtable. This coincided with the third signing ceremony for the WA CP Statement and the release of the resource materials for the small business support program. Each program

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Table 3
Overview of the small business support program

<table>
<thead>
<tr>
<th>Target group</th>
<th>Aim</th>
<th>Format</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrepreneurs (owners and operators of small to medium sized enterprises) [107]</td>
<td>Raise awareness for business and environmental benefits of CP (level 1)</td>
<td>20–30 minute awareness raising session (often integrated in other industry event)</td>
<td>12 minute video and checklist</td>
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<tr>
<td></td>
<td>Create understanding of CP opportunities (level 2)</td>
<td>1.5 hour workshop (typically co-hosted by industry association or local government, could be made sector specific or cover multiple sectors)</td>
<td>Participant’s workbook</td>
</tr>
<tr>
<td></td>
<td>Enable implementation of CP in own business (level 3)</td>
<td>5 workshops of 1.5 hours, leading to development of CP action plan specific to own business (typically delivered to groups of 5–10 businesses, either from one industry sector or from range of industry sectors)</td>
<td>Participant’s manual</td>
</tr>
<tr>
<td>Intermediaries (e.g. local government, staff, catchment coordinators, industry association staff) [108]</td>
<td>Facilitate participants to become CP advocates in their day to day work</td>
<td>3 workshops (half day) plus site visits and participants’ case studies (typically delivered to groups of 10–20 participants)</td>
<td>Participant’s manual</td>
</tr>
<tr>
<td>Practitioners (e.g. consultants, environmental managers)</td>
<td>Develop participant’s knowledge of and skills in CP tools</td>
<td>One day training program (typically delivered to groups of 8–15 participants)</td>
<td>Participant’s manual</td>
</tr>
</tbody>
</table>
described here had reached a degree of maturity and demonstrated its applicability and effectiveness in at least a dozen businesses.


The challenge now changed to scaling-up of programs, i.e. to replicate their success in significantly larger numbers of organisations with a significantly lower effort per organisation. This coincided with a marked increase in the consultation efforts for the development of a WA State Sustainability Strategy (for which the initial consultation paper had been launched in December 2001 [25]). The roll out of the key programs is first summarised, followed by the new trends and topics that started to surface.

5.1. Small Business Support Program

The CECP maintained ownership and responsibility for the roll out of the Small Business Support Program. It provided annually three availabilities of its implementation program (level 3), one availability of its stakeholder and practitioner programs and co-hosted level 2 introductory sessions in collaboration with a range of local government and industry stakeholders (as per Table 3). Moreover it developed sector specific information sheets for food [56], metals [57], printing [58] and health care industry [59], and 16 additional WA company case studies.

The programs were widely supported and advertised through industry associations, local governments and catchment groups, and the benefits for the participants remained consistently high. The average annual savings from comparatively straightforward opportunities identified through participation in the implementation program was about A$4000. The participation levels however remained low, with an annual average of ten organisations in the implementation program (for 2002—2004), thirty-five in the introductory program (2003—2004), nine in the intermediaries program (2002—2004) and six in the practitioners program (2002—2004).

In its 2003 review, CECP identified three (clusters of) pertinent barriers towards the greater consideration and implementation of CP specifically among SMEs:

- Misunderstandings of nature and benefits of CP. That is, a narrow interpretation of potential benefits focused on environmental risk reduction;
- Moderate to low levels of environmental awareness and compliance, as a result of comparatively low environmental and resource use costs, and limited enforcement activities on environmental regulations; and
- Volatile nature of small business, including its ownership and workforce.

CECP therefore increasingly focused its communications towards positioning CP as a business efficiency and business risk reduction strategy.

5.2. Learning-by-Sharing Program

Enthusiasm for the Learning-by-Sharing Program offered through the WA SIG remained high over 2002—2004, as reflected in the doubling of its participants’ base between February 2002 and April 2004 (to 475 participants representing 275 organisations). The management and delivery of the program matured over this period, with a division of program events in four main categories:

1. **Best practice seminars**: once-off topical seminar with several case study presentations and forum session, on for example: sustainable development reporting, greening of supply chain, life cycle assessment, environmental management systems, etc.);
2. **Policy forums**: consultative forums on aspects of government policy for sustainable development, aligned with the development of the WA State Sustainability Strategy [23,25];
3. **How-to’ workshop series**: series of workshops on interrelated topics providing participants with practical tools to implement EE in their own organisations, in particular the Energy Efficiency and Management Series (2002—2003) and the 2004 Eco-Efficient Entrepreneur Series); and
4. **News and alerting service**: through an electronic newsletter on EE and Corporate Sustainability issues with relevance to WA businesses and other organisations.

5.3. WA CP Statement

Signatories commit to develop and implement an Action Plan to implement CP in their operations and/or promote CP among their constituency. Fig. 3 shows that the rapid growth over the first 12 months slowed down as a result of reduction of the recruitment drive. From the total 108 organisations that became Signatory at any of the first eight signing ceremonies, 91 remained as active Signatories by the end of 2004. Nine had been removed, five of these as a result of failure to deliver on the commitment to develop an action plan, and four upon the organisations’ own request (three of these after completion of their initial two-year commitment period). Five government signatories merged into two new government departments and two tertiary institutions merged, leading to three ‘new’ signatories taking over the initial commitments from seven initial signatories.

Fig. 4 shows the Signatories by organisation type. Fig. 5 shows the efforts of the Signatory Organisations with regard to the development and endorsement of their action plans. As of December 2004, 69 Signatory Organisations have an action plan in place (76% of the active Signatory Organisations). Given the lag-time between becoming signatory and the formal obligation to submit an action plan, the level of formal non-conformance with the action plan commitment remained comparatively low (10%). Although the WA SIG would be entitled to remove the nine non-conforming signatories from the
Register, it has not yet done so, as all appear to be working on the promotion and/or implementation of CP.

The actions taken by Signatories typically cover five categories:

1. **Implementation within own operations**: development, evaluation and implementation of CP opportunities within Signatory’s operations.

2. **Awareness, promotion and recognition**: promotional activities of the Signatory to foster consideration of CP by its constituency, e.g. members, staff, suppliers, contractors, customers, etc.

3. **Policy, advocacy and regulation**: policy, networking and lobbying initiatives of the Signatory to create a policy and regulatory environment conducive to the consideration and implementation of CP.

4. **Education and training**: delivery of award and non-award courses by the Signatory to increase knowledge and skills of industry’s (para-) professional staff and students on CP.

5. **Research and development**: (applied) research conducted by the Signatory to develop and support the implementation of novel CP technologies, practices and policies.

‘Implementation’ and ‘awareness and promotion’ are the most frequently occurring actions, each typically addressed in around 75% of the action plans, followed by ‘policy and advocacy’, typically addressed in around 60% of the action plans [60]. ‘Research and development’ and ‘education and training’ are the least frequently occurring type of actions, with coverage in approximately 25% of the action plans. Two years into their commitment period, Signatories are requested to provide an outcome statement against their initial action plan. Table 4 summarises some outcomes statements.

5.4. Green Stamp Program

The MTA maintained a strong ownership of the Green Stamp Program, which received great interest from other industry sectors and states for its practical and sector-specific approach to raising SME’s environmental awareness and improving compliance. As a result Green Stamp became a national program for the motor trade sector in early 2003 and a multi-sector initiative in WA in late 2003 (with the launch of pilots in the printing and cleaning industries).

Although initially designed as an environmental accreditation scheme, over the years it evolved more and more into an industry association-led environmental awareness and capacity building program. Key program activities are now:

- Provision of obligation-free environmental audits;
- Compilation of industry specific environmental guidelines;
- Publication of environmental service providers’ directories; and
- Delivery of industry specific environmental training [52].

While interest in the environmental awareness components has remained high, this appears not to have been matched with similar interest in the accreditation scheme. The number of Green Stamp accredited motor trades businesses increased...
from 10 at the launch of the accreditation register in November 2002 to 26 in April 2005 [61], with no differentiation between level 2 and level 3 accreditations. The first six printing industry Green Stamp certificates were awarded in December 2004 [62], while no accreditations had been awarded in the cleaning industry by April 2005.

5.5. New initiatives

Simultaneously the focus of the CP and EE initiatives in WA started to broaden, outside their traditional domains of in-plant resource efficiency drives. Prominent new foci were:

1. **Supply chain management**: the recognition that an important part of the environmental footprint of businesses and in particular service organisations is defined by the organisation’s procurement of goods and services, sparked interest in greening of supply chain initiatives. The WA SIG dedicated a best practice seminar to this topic in early 2003 and its importance was further highlighted in the health care sector project by CECP [59,63]. Simultaneously a significant local capacity for life cycle assessment (LCA) was created with the execution of a prominent research project into the applicability of LCA for improving the EE of grain-supply chains [40]. This included in depth case studies on bread, beer and cooking oil [64].

2. **Industrial symbiosis** [65,66]: this involves businesses, other organisations and the community in exchanges of previously wasted resources (materials, energy, water, etc.) for net competitive and environmental advantage (see e.g. [67]). Three quite distinct examples started to surface in 2001–2002 in WA and gained significant momentum thereafter.

   a. Kwinana Industrial Area: a heavy industrial area at the southern end of the Perth Metropolitan area is home to alumina, nickel and oil refineries, chemical, pigment and cement plants, power stations and a diversity of supportive industries. A 2001 study into the economic impacts of the area, identified impressive lists of up to 100 existing and potential synergies, including for example cogeneration plants, exchanges of industrial gases, water recovery and reuse schemes and useful applications of selected inorganic waste streams [68–70].

   b. Shenton Sustainability Park: the WA Water Corporation aims to attract compatible business activities into the buffer zone of the Subiaco waste water treatment plant in the Perth metropolitan area, and use this as an incubator for research, technology transfer and education on sustainable urban living [71].

   c. Narrogin: the integrated wood processing pilot project in rural Narrogin [72], combines planting of Mallee trees to combat dry-land salinity, with the use of the wood crop for integrated production of high grade charcoal, eucalypt oil and renewable energy.

3. **Corporate sustainability**: a number of factors contributed to a general broadening of the agenda from strictly resource efficiency and environmental improvement to the broader business case and agenda for sustainable development. Contributing factors included: public consultation processes as part of the development of the WA State Sustainability Strategy; persistent community concerns about environmental health impacts of key industrial facilities;

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The creation of regional resource exchange networks is also referred to as Industrial Ecology. This is however a broader field that studies “the flows of materials and energy in industrial and consumer activities, of the effects of these flows on the environment, and of the influences of economic, political, regulatory and social factors on the flow, use, and transformation of resources”. Industrial Symbiosis is therefore better regarded as one of the prominent subsets within Industrial Ecology.

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The reported synergies in this study included both ‘regular’ supply synergies (approximately 2/3 of the reported synergies) and industrial symbiosis involving by-product synergies (approximately 1/3 of the reported synergies).
Table 4
Example outcomes achieved and reported by Signatories to the WA CP Statement (Feb 2004) [60]

<table>
<thead>
<tr>
<th>Signatory</th>
<th>Category</th>
<th>Reported outcomes</th>
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| Alcoa World Alumina Australia — WA Operations | Business | • Investigated feasibility of residue neutralisation, and adopted plans for progressive implementation at Kwinana by 2006  
• Planned trial for 2004 on sand separation and reuse from bauxite residue  
• Built water pumping station to harvest and use lower quality feed water for Pinjarra refinery  
• Commissioned feasibility study into 2GL water reuse from Mandurah’s waste water treatment facility  
• Approved construction of cogeneration plant at Pinjarra Refinery  
• Major industry partner to the Collaborative Research Centre for Sustainable Resource Processing |
| SIOG Hospital — Subiaco | Business | • Environmental management policy has been documented and approved  
• Environmental responsibility is added in all job descriptions and comprehensive staff education strategy is in place  
• Electricity and gas consumption dropped by 2% and 18% respectively during 2001–2002, and remained constant in 2003 despite 3% growth in used floor space  
• Progressive replacement of sterilisers with more water efficient sterilisers  
• Reduction of clinical waste generation by 8%, as a result of better housekeeping |
| Hatch Associates | Business | • Adopted sustainable development as core principle in corporate manifesto and standards  
• Reviewed plant design practices and developed a sustainable plant design framework which is being trialled in clients’ engineering design projects  
• Added CP and eco-efficiency to the standard technology evaluation procedures |
| Kwinana Industries Council | Industry association | • Implementation of Kwinana Regional Synergies Initiative, including assessment of the economic contributions and environmental initiatives of industries in the region and facilitation of the development of new synergy initiatives with regard to water reuse, coordinated recycling of dry recyclables and energy efficiency |
| Drycleaning Institute of Australia (WA) | Industry association | • Included CP principles and practices in induction booklet for industry operators  
• Implemented training program on safe handling of PERC solvents  
• Facilitated the development of three dry-cleaning CP case studies |
| Department of Environment | State government | • Developed an Eco-Office Guide (to reduce energy and paper consumption in the office, replace hazardous materials and reduce traffic), implemented it in own operations and assisting other government agencies with implementation  
• Coordinated the development of a three tier awareness, training and implementation program for CP in small businesses  
• Promotion of CP and eco-efficiency through the annual WA Environment Awards  
• Leading contributor to the whole-of-government water and greenhouse strategies |
| Wheatbelt Development Commission | State government | • Provided a liaison between primary producers and industry in the region and the WA Sustainable Industry Group  
• Adopted CP in the region’s strategic plan and incorporated in the regional Natural Resource Management Strategies |
| Swan TAFE | Tertiary education | • Developed and started delivery of professional courses on installation of cleaner technologies, such as energy saving electrical designs and devices in homes, CNG motors, smart controls for air-conditioning, etc.  
• Implementing an energy smart program to reduce energy use by 12% over 5 years |
| Curtin University of Technology | Tertiary education | • Restructure of undergraduate engineering degrees to incorporate CP and engineering sustainable development progressively into all engineering curricula (from 2004 onward)  
• Continued operation of Centre of Excellence in CP and WA Sustainable Industry group to foster consideration and uptake of CP in the Western Australian industry  
• Success in acquiring major new sustainability-inspired research initiatives, such as for instance the Collaborative Research Centres for Sustainable Resource Processing, Desert Knowledge, Sustainable Tourism and Greenhouse Technologies |
| Environment Institute of Australia | Professional association | • Promotion of the activities of the WA SIG to its membership basis  
• Adopted CP and eco-efficiency as core themes for the association’s national conference |

the World Summit on Sustainable Development, including the release of national and international industry and community contributions thereto (e.g. [73,74]). The extension into Corporate Sustainability was reflected in the 2003 revision of the Charter for the WA Sustainable Industry Group, and increasingly supported by businesses and industry and professional associations.

The roll out period ended in mid-2004, as the programs did plateau and faced more profound competition. The closest
transition date would be 2 July 2004, at the occasion of the 5th anniversary celebrations for the WA SIG. This was just after the creation of the WA State Sustainability Roundtable to advise government on the implementation of its State Sustainability Strategy. It also marked the end of the funding support from the WA Waste Management and Recycling Fund to the CECP to act as convenor and facilitator for the WA SIG.

In hindsight the roll out period was a period of both excitement and frustration. The growth of the Signatory Register to the WA CP Statement and the level of conformance of Signatories by far exceeded the initial expectations, and indeed created a groundswell of initiatives, involving a growing diversity of stakeholders in the uptake of CP and associated concepts and tools. Meanwhile however there was also disappointment that existing programs were not able to achieve significant scale-ups, while the evaluation of the effectiveness of different programs was further complicated by a general lack of consideration of program monitoring and evaluation issues.

6. Reorientation (2004–?)

Reflecting on the mixed results in the roll out phase, two grand challenges emerged. The first challenge is to motivate more businesses to consider and implement CP and EE. It is a challenge primarily for the design and contents of CP programs and exists most profoundly for SMEs. The second challenge is to assist organisations with demonstrated CP commitment more effectively in identifying and implementing their best CP solutions. It is a challenge primarily for the CP methods and technologies and exists most profoundly for process industries. Even though no definitive answers have been found so far, the following provides some background to each of these two grand challenges and scopes potential ways forward.

6.1. Design and contents of CP programs

Information-based promotional strategies have traditionally dominated CP programs for small businesses (e.g. [9,75–77]). Policy makers and CP facilitators alike have reverted to different theoretical bodies to underpin and improve CP strategies, most profoundly to environmental psychology and technology diffusion theories.

Environmental psychology investigates why individuals and—to a lesser degree—organisations adopt environmentally preferred behaviours, such as source separation for kerbside recycling, use of public transport, and uptake of energy and water saving devices and practices. The insights gained have been integrated into what is now known as Community Based Social Marketing (CBSM) [78]. Its effectiveness is due to its pragmatic approach, which involves: identifying barriers to a sustainable behaviour, designing a strategy that utilizes behaviour change tools, piloting the strategy with a small segment of a community, and finally, evaluating the impact of the program once it has been implemented across a community.

CBSM has demonstrated its effectiveness for comparatively simple changes in routine individual behaviour, in regards to energy and water use habits, waste segregation practices, purchasing decisions and transport choices. In the framework of CP promotion, CBSM provides an opportunity to strengthen the involvement and participation of employees in good housekeeping type measures, such as effective sorting of waste streams, more conscious use of personal protective equipment (earplugs, gloves, etc.), double sided printing and copying and switching off lights and office equipment. Organisations that have been comparatively effective in engaging their staff in CP, such as Westpac [79] and St John of God Healthcare Subiaco [63], have either incidentally or purposefully adopted many of the CBSM concepts in their extensive environmental education strategies.

Application of CBSM to motivate companies to consider CP is however faced with a series of interrelated difficulties:

- Being a problem solving and opportunity creating strategy, CP does not lend itself to pre-programmed behaviours that can be universally replicated.
- CP will often require new skills and capabilities, that need to be ‘learned’—at the individual as well as the institutional level—and will not simply result from buying another oil, cleaner or paint for running the business.
- CP uptake is the result of a sequence of behaviour changes by different individuals and departments in an organisation, as compared to the direct ‘action—result’ relation that exists with changes in individual behaviour. Someone in the organisation has to take the lead to start considering CP, convince management to change its behaviour, seek involvement of staff in development and evaluation of CP options, seek approval for implementation and secure staff involvement in implementation.

A competing school of thought considers the uptake of CP as an example of a technology diffusion process. Technology is then broadly understood as the application of technological knowledge, including equipment, operational and maintenance protocols, management systems and skills. Three competing technology diffusion models exist [80]:

- The epidemic model assumes that uptake of new technology will progress autonomaically upon provision of an endogenous mechanism, most profoundly information on the technology availability and its benefits.
- The threshold model assumes that new technology will only be considered and adopted once a critical threshold has been achieved, for example the collapse of a traditional market, stringent environmental conditions/discharge limits, or steep increase in relative costs.
- The forces model assumes that adoption of new technology is the result of the—organisation-specific—interplay between six groups of factors: economic consequences; regulatory pressure; market growth; applicability of technology; societal pressure; and business and other risks.

On the basis of technology specific studies [80], it appears that the forces model best explains factual technology
diffusion, as it incorporates the decision-making context of the organisations adopting the new technology. Moreover, the forces model can be used to employ tacit knowledge of experts to predict patterns and rates of technology diffusion.

The broad implication of technology diffusion theory for promotion of CP is that CP and EE depend on companies becoming pro-active. Proactive companies seek improvements on their own as part of their competitive strategies rather than in response to specific regulations [81]. This does not happen on its own, despite some stimuli for it. Making companies pro-active requires change at multiple levels: the government-business relation has to change, producers and consumers must develop new competencies and the economic conditions have to change too. WA SIG is an example partnership that fostered more proactive business, government and community attitudes and practices.

Armed with insights from innovation diffusion theory CECP developed and piloted a two-tiered approach to engaging small business in CP initiatives. The first tier comprises of a semi-structured telephone introduction with small business operators to discuss their business efficiency, innovation record and environment and energy management. The introduction is designed to raise business awareness for the cost of resource use in their business (in particular energy, water and materials use and waste and waste water disposal). The second tier is a preliminary on-site appraisal of the likely size and nature of the business opportunity that might arise from the implementation of CP in the given business. The consultant assists the company to compile an inventory of key areas of waste generation and water and energy uses, and estimates the proxy costs to the business. This results in an eco-map [82]. The approach was pilot tested in the Malaga Industrial Area (in Perth), and its results were used to produce a guidance manual for local government to engage small businesses in CP [83].

In the Malaga pilot, 122 firms were randomly approached [83]. Thirty-five firms dropped out as they no longer had operations in Malaga or their manager was not available. Of the 87 managers (or equivalent owner) spoken to, 48 completed the introductory phone conversation. For 23 of these a preliminary on-site appraisal was completed. Overall, the approach had a success rate of 1 in 3 in terms of being able to introduce CP and talk about resource efficiency issues with the business owner or manager. The success rate for completing an on-site preliminary appraisal was one in six from the businesses initially approached through the cold calling method. This compared very favourably with other written communication efforts, which typically have had a turn out of at best 1 out of 20—30 written invitations. Twenty-seven percent of the business managers to which CP was introduced, appeared to have no idea of resource costs, while about half had at least some idea (in most cases they were aware of energy costs). While only three businesses had heard about CP, 30% of the businesses visited displayed some simple CP practices: sky-lighting; dry clean up before wet cleaning of work places and equipment; installation of energy efficient equipment; and reuse of packaging from incoming goods for products. For all 23 businesses that completed the on-site preliminary appraisal new opportunities were identified. Given the limited time spent for the preliminary appraisals (typically 0.5—1.0 hour), the opportunity identification was biased for good housekeeping and comparatively simple technological fixes.

6.2. CP methods and tools

Materials and energy intensive process and utility industries are generally well aware of the business imperative to use natural resources efficient to remain competitive. While commitment to EE is therefore not at stake, there remains a degree of scepticism regarding the incremental benefits of explicit consideration of EE compared to existing internal resource efficiency drives. This scepticism has a two-fold basis. First, as EE outcomes have been achieved in the past through regular process and project development, without specific consideration of EE objectives or CP practices, it is questioned why specific EE initiatives would still be necessary. This is further reinforced by the many environmental and energy audits that have only addressed peripheral use areas (such as lighting and air-conditioning in offices and warehouses), while not addressing the principal uses in the core processes. Second, mainstream CP tools appear not suitable in heavy processing industries. The traditional engineering based approaches [84] rely heavily on mass balances. These are however resource-intensive to establish for complex process systems that involve multi-phase reactions and complex materials with fluctuating chemical, mineralogical and physical properties. Moreover, these often do not capture the components of principal environmental concern, such as the minor elements or the comparatively small losses from process streams. The systems based [85] and quality management approaches [86] on the other hand are often considered too simple to initiate option identification in complex process environments.

There is a degree of optimism that systemic and explicit consideration of CP and EE in project and process development can generate better and more eco-efficient outcomes (e.g. [87—89]). There is some evidence that more eco-efficient plants have been achieved where engineers and managers have more vigorously pursued EE objectives [90]. The challenge remains to provide frameworks, tools and metrics that can feed and anchor EE thoroughly in mainstream project realisation cycles, rather execute EE opportunity assessments upon project completion. Preliminary, largely conceptual, efforts show that such might be possible, even though this is still far from being widely applicable in the engineering design teams [91,92].

Likewise there is optimism that the limitations in CP tools as organisational change agents [93,94] can be addressed through the application of insights from organisational change theory and practice [95—97]. These efforts appear to have been most useful in explaining ex post the level of success and appropriateness of CP interventions in businesses. The guidance for improved design and implementation of CP initiatives derived from such business analyses, has been mostly conceptual [94,97], and uncertainties remain over its effectiveness. While organisational change initiatives favour values or
principles driven top-down implementation of CP initiatives, others highlight the opportunity for bottom-up approaches based on established lean manufacturing and business improvement concepts, such as Kaizen engineering (or total productivity management, [98]) and six sigma management [99].

7. Discussion

The uptake of CP and EE in WA appeared to have lagged behind the uptake in the rest of Australia during the 1990s. This appears understandable in the context of the limited size and relative isolation of WA, the dominance of the minerals, energy and agribusiness sectors and local business—government relations. A concerted effort to define and clarify concepts, strategies and programs, and their subsequent roll out, resulted in a remarkable growth of CP activity in a relatively short period of time. The WA Sustainable Industry Group was of particular significance, in particular through its innovative use of a voluntary partnership program using the WA CP Statement. This was however only possible through the support of the Centre of Excellence in CP, the widespread buy in from the private sector, government and professional and community organisations, and a conducive political environment with sustainability high on the agenda of the state government and key industry sectors.

The growth in the uptake of CP and EE started to level in 2004, for a number of reasons, both external and internal to CP. External reasons included greater competition on the corporate sustainability agenda (due to greater prominence of other sustainability topics including transparency, sustainable technology and corporate social responsibility), drying up of dedicated funding support for CP and EE programs, the unprecedented growth experienced across the resources industries since 2003, and the eminent shortages in water and power supplies in particular in the South Western part of the state. Simultaneously however, there is also growing evidence that WA has approached the limits of CP and EE theory and practice. This applies both to designing and delivering programs that can achieve a step-increase in the number of businesses (in particular small businesses) that consider and implement CP as well as to providing the engineering, management and other tools to enable inclusion of CP in plant design and optimisation in the process and utility industries. New directions have been identified to drive CP and EE to their next tiers of application, through greater application of technology diffusion theory and practice in program design and delivery, and greater engineering and management depth in CP methods and tools, in particular for complex processes and organisations.

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