Assessment of cleaner production uptake: method development and trial with small businesses in Western Australia

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Abstract

This paper reports on the development of an innovative semi-quantitative assessment method to estimate the level of uptake of cleaner production (CP) in small to medium-sized enterprises (SMEs) on the basis of three component ratings: awareness of CP ideas and benefits; presence of management features and/or system components conducive to CP; and CP content of recent innovations and operational improvements. The assessment method was designed for application through a telephone survey and was deliberately structured to minimise intentional socially preferable responses. It was trialled on 140 SMEs in four sectors, mostly from Western Australia: printing and book making; dry-cleaning; food processing and metal products. The trial showed that the assessment tool can judge the business' capacity to implement CP. The levels of CP uptake found in the trial reflect well on the experience of CP practitioners, albeit much lower than reported from previous mail surveys. In the trial the drycleaners performed significantly better than the other businesses, with food processing, metal processing and printing businesses being ranked second, third, and fourth respectively. The higher uptake by drycleaners was expected given that a sector specific CP program was conducted in that sector. Overall, the results suggest that generic (non-industry specific) semi-quantitative proxy indicators can be used for estimating the level of CP uptake in SMEs. Although further verification with quantitative environmental and economic performance data would in principle be desirable, this would be impractical due to the general lack of monitoring and recordkeeping of environmental data in many SMEs, and would also face the common conceptual, methodological and fundamental challenges for CP quantification. The tool may therefore be more useful to target CP promotion efforts, and measure their effectiveness.

Keywords: Cleaner Production; Eco-efficiency; Australia, SMEs

1. Introduction

Cleaner production (CP) and eco-efficiency (EE) are often used interchangeably, even though they differ significantly in their strategic intent [1,2]. CP is most commonly understood as positive economic benefits arising from efficient use of materials and energy. EE is concerned with positive environmental benefits from economic efficiency. The United Nations Environment Programme (UNEP) defined CP as “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” [3]. Vickers et al. [4] favoured Jackson’s [5] definition of CP: “an operational approach to the development of the system of production and consumption, which incorporates a preventative approach to environmental protection”. EE is best characterised as “creating more value with less impact” [6,7]. The World Business Council for Sustainable Development (WBCSD) defined EE as 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 lifecycle to a level at least in line with the earth’s estimated carrying capacity” [6,7]. A number of highly comparable other terms are...
commonly used in other jurisdictions and industry sectors, including: pollution prevention, toxics use reduction, design for environment, and industrial ecology [1,8].

CP and EE overlap and could very well have the same outcome when applied in a given business process or context despite perspectives differing according to whether the business objective is to cut costs, through EE, or to minimise environmental impacts, through CP. This is further illustrated by the fact that CP is most commonly further described in terms of a set of operational practices (the means) while EE is further described in terms of EE elements (the objectives). The most commonly used CP prevention practices are: good housekeeping; technology modification; input substitution; on site recovery, reuse and recycling; and product modification [1,3,8–10]. EE includes: reduction of material intensity of products and services; reduction of energy intensity of products and services; reduction of the dispersion of toxic materials; enhancement of material recyclability; extension of product lifetime; use of sustainably sourced renewable resources; and increase of the service intensity of products [1,7].

There has been a consistent growth in the number of publicly documented case studies of CP implementation in a wide range of industry sectors and business sizes, both in Australia [1,11] and internationally [12–15], since the early 1990s. These practical examples suggests that CP is widely applicable [16] and generally delivers both environmental and competitive advantage [2,6], even though the theoretical debate whether being green can be competitive is far from resolved [17–19]. Meanwhile however there remains great uncertainty about the actual level of implementation of CP in businesses, in particular among small to medium sized enterprises (SMEs) (e.g. [20,21]).

The research reported here aimed to develop and trial an innovative, generic assessment method for estimating the level of consideration and implementation of CP, with particular applicability in SMEs. Section 2 summarises key considerations in measuring CP, both quantitatively as well as qualitatively. Section 3 reviews Australian environmental management surveys. Next the design of the assessment tool is described in detail (in Section 4). The trial findings are summarised in Section 5, while Section 6 draws conclusions both with regard to the trial and possible applications of the assessment tool.

2. Measuring cleaner production

Despite a growing international interest in CP measurement over the last decade [15,22] there remains a great deal of uncertainty on how to measure CP/EE results properly. Measurement of the actual environmental and economic performance improvements would be preferred, but such is not straightforward at the firm level, as:

- Conceptually, measuring CP results is faced with the fact that what needs to be measured no longer exists (i.e. the avoided waste stream or resource consumption). It is therefore most common to compare the company’s environmental and economic performance before and after implementation of a CP project. However, even though the CP project might reduce or nearly eliminate a specific waste stream, this does not necessarily show up in the company’s overall environmental performance, if for example the reduced waste stream was a small contributor to the total waste stream of the company, or if product mix and/or output change. Tracking trends in the company’s environmental performance over time however remains the most desirable CP quantification.

- Methodologically, environmental performance trend data need to be normalised against a meaningful indicator of business activity. This would typically lead to the use of (pollution) intensity indicators, expressed as net environmental impact (e.g. tonnes of waste, water use) per unit of production or sales (operational environmental performance indicators as in ISO 14031 [23]). Alternatively, efficiency ratios can be measured, i.e. the economic value created (in production units or financial turn over or profit) per net unit of environmental impact caused (e.g. total energy and water consumption [24]). Even though pollution intensity or eco-efficiency ratios can be regarded as best practice CP measurements, they cannot capture trade-offs, i.e. where one environmental impact category (e.g. waste water) improves at the expense of another environmental impact category (e.g. energy use), or where chemicals with different environmental impacts are being substituted (e.g. ecosystem toxicity versus human toxicity). While life cycle impact assessment tools can in principle be used to assess such trade-offs, there is only very limited experience in doing so [25].

- Fundamentally, CP is an environmental business improvement strategy, and the absolute or relative level of CP result, that is the level of environmental business improvement, does not consider the absolute performance levels before or after CP implementation [26]. An equal level of CP achievement, for example a 20% decrease in water pollution load, would be far more significant for a company already operating near or at industry best practice compared to a company that is catching up from being well below industry best practice. De facto, this approach penalises the industry leaders, as it is more challenging for them to achieve further substantial improvements then for the industry laggards.

In addition to these conceptual, methodological and fundamental considerations, the reliability of quantitative assessment of CP results ultimately depends on the comprehensiveness, reliability and integrity of the monitoring of environmental records at the company level. While larger businesses have generally moved to adopt best environmental performance monitoring systems [27], such systems are generally defunct or not existent in SMEs (e.g. [20,21,28]).

To bypass data problems, many studies and program evaluations have focused on the number of CP measures considered or implemented (e.g. [12,15,29,30]). Doing so is however also not very satisfactory as the number of options neither reflects upon the complexity of implementation nor upon the size of
environmental and financial impacts of the implemented options. A simple housekeeping measure, for example fixing a tap, counts equally to a complex process change, for example inclusion of a process-integrated reuse/recycling system [16,31].

Qualitative, or semi-quantitative, measurement schemes can also be linked to the CP technology diffusion process or to the impact of the CP uptake on the business.

- CP uptake can be viewed as a specific example of technology transfer, broadly understood as technical innovation through transfer of ideas, knowledge, devices and artefacts from leading edge companies, R&D organisations and academic research to more general and effective implementation in industry and commerce [32]. A generic four activity descriptive framework can be used for such inward technology transfer [32]:
  1. Awareness: the processes by which an organisation scans for and discovers what information on technology is available;
  2. Association: the processes by which an organisation recognises the value of this technology or ideas for the organisation;
  3. Assimilation: the processes by which an organisation communicates these ideas within the organisation and creates generic business opportunities; and,
  4. Application: the processes by which an organisation applies this technology for competitive advantage.

- The effectiveness and depth of CP uptake can also be rated on the basis of the impact of the CP project on the company. For example, the greater savings, the better alignment with business priorities and/or the greater staff involvement in the CP project, the more likely the company develops a CP ethos, as a basis for further CP achievements in the future. Van Berkel [16] proposed an evaluation scheme that has since been used in several post-implementation reviews of CP programs [33–35]. It rates effectiveness in three areas:
  1. Practical value: the economic and environmental effectiveness, and operational feasibility of the CP opportunities identified;
  2. Technical impact: the innovativeness of the CP opportunities identified, which enhance the likelihood that their implementation will have a lasting impact on the technology selection, operation and maintenance of the company;
  3. Systemic impact: the degree to which the CP uptake has contributed to changes in management and information systems, organisation structure and corporate culture of the organisation, which enhances the likelihood that CP uptake will have a lasting impact on the day-to-day management of the company.

3. Environmental management surveys

Several studies were conducted in Australia to determine industry’s current environmental performance. Kestigian [36] found that matters dealing with the environment were considered, by most companies, to be backburner issues, consuming valuable resources better spent elsewhere. Frost and Wilmshurst [37] surveyed chief financial officers of the top 500 Australian companies to determine the level of adoption of environmental accounting practices. Only 43% of respondents believed that environmental information was important to the users of annual reports.

Holmes and Girardi [38] surveyed corporate environmental practices and environmental strategy adoption in manufacturing companies with a written questionnaire and follow-up interviews of selected firms. Of the 153 respondents (response rate of 16%), 85% claimed to have implemented Waste Minimization in the past, 45% CP and 5% EE. However, few respondents explicitly merged productivity and environmental issues—the essence of effective implementation of CP—as only few companies reported that environmental management issues had a significant influence on their production strategies.

The adoption of preventive environmental management practices was found to lag behind the general advance of the environmental management function. They found that little information existed to assess the extent of linkages between environmental improvement, productivity initiatives and competitive strategy, while such information is essential to develop appropriate government policies, incentive systems and educational strategies.

Greene [39] interviewed 53 businesses that were identified by their industry and government peers as sector leaders to determine the existing structures, operations and planning within manufacturing organisations to support CP implementation. The results showed that 85% of the respondents claimed to be aware of CP. The responses however also indicated that companies that have employed CP methods have not moved from use on one project to comprehensive use in all operations.

Andrews et al. [40] investigated the awareness and adoption of CP in SMEs in the Geelong region using a mail survey, distributed to 500 businesses. The 145 respondents (response rate 29%) demonstrated a low familiarity with CP (only 28% of respondents were aware of CP). Nevertheless, there was a fairly high awareness of the environmental and economic advantages of CP-like measures. It was also found that the majority of CP practices are of a good housekeeping nature, reflecting the embryonic nature of the CP approach in these businesses.

Zutshi et al. [41,42] researched the experiences of Australasian organisations with the implementation of environmental management systems (EMS). They obtained 132 completed surveys from the 286 certified organisations approached (response rate of 46.2%). Only 14 respondents had 19 or fewer employees. The reported highest-ranking benefits of EMS adoption were: protection from prosecution, fines and legal fees, reduction in organisational risks (health, safety and environment) and compliance with regulation [41]. Remarkably it turned out that establishing and monitoring CP and EE targets was the only benefit for which the expectations were higher than the actual achievements [42]. Moreover it was found that employees were the most important stakeholders in EMS adoption, with only few organisations working directly
with suppliers [42]. It was also found that the cost benefit analysis for EMS implementation was troubled by the difficulty to put a dollar value on the intangible benefits like improvement of corporate image. An opportunity was found for streamlining EMS adoption through integration with other management systems, for example for quality management [42].

The Australian Chamber of Commerce and Industry conducted a mail EE survey in late 2002 [43], to which 330 of its member businesses responded. The survey focused on environmental activities and outcomes, and the interplay of barriers and motivators. In terms of activities, waste recycling and reuse turned out to be the only environmental activity widespread among businesses of all size (at least 2/3 of companies in each size category engaged in waste recycling). Uptake of any of the other environmental activities, including CP-focused activities like design for environment, environmental purchasing and life cycle assessment, was well below 20% of small businesses. Uptake by medium and large businesses was higher, in particular for environmental audits (50% of large and 37% of medium businesses) and nature conservation (33% of large and 19% of medium businesses) and environmental purchasing policy (32% of large and 21% of medium sized businesses). In terms of environmental outcomes, the most frequently reported environmental outcomes are waste reduction, energy conservation and materials conservation (each reported by at least half of the respondents of each business size). Overall, environmental outcomes occur more frequently in medium and large businesses than in small businesses. The differences between medium and large businesses appear to be marginal, if present at all. The three most frequently mentioned barriers were: cost of implementing improved operations (35% (small) to 55% (large businesses)); lack of time (35% (large) to 46% (medium businesses)); and lack of commercial benefit from improved operations (33% (small) to 43% (large businesses)). A remarkable finding was that all barriers are more frequently reported by medium businesses than by small businesses (with the exception of virtually equal occurrence of lack of knowledge on alternative ways of operations). With regard to motivators, three stand out as the most common motivators: increased environmental awareness (52% (small) to 68% (large businesses)); cost savings (39% (small) to 56% (large businesses)); and compliance with regulations (25% (small) to 50% (medium and large businesses)). Motivators are less frequently experienced and reported by small companies than by their medium and large business peers. An overall energy intensity indicator was calculated across all respondents: 3.7 MJ/AUD\$ turnover.

The Swan-Canning Industry Survey [44] is the most significant effort in Western Australian. It determined potential threats to the Swan River by site inspections and assessment of more than 520 light industrial premises. The uptake of CP was however not investigated with any great depth.

4. Assessment method

This research aimed to develop an assessment method that could provide a proxy-indicator for the level of consideration and implementation of CP. During initial scoping it was found that indirect questioning on the implementation of CP through mail surveys a number of compounding errors occurs, particularly: low and selective response (only those who take the environment seriously will commit to return environment related surveys) and biased responses for socially-preferred, environmentally sound business activity. Moreover the nature of SMEs (in particular their often informal structure, high turnover of staff and businesses, etc.) does not lend itself to a rigorously quantitative assessment on the basis of documented and measured emissions, waste generation, and water, energy and materials consumption.

The method merged elements of the technology transfer process with the evaluation of the impact of the CP uptake on the business. It was structured to elicit one score for:

1. **Awareness**: indicator for the level of awareness of CP, with particular reference to the underlying ideas and practices, and awareness of the potential for environmental and economic benefit;
2. **Management**: indicator for the presence of key environmental and resource management features and tools within the business, reflecting the level of incentives created within the business’s day-to-day operations to identify and pursue CP opportunities;
3. **Implementation**: indicator for the actual implementation of CP, or similar opportunities within the business over the preceding three years.

The awareness and implementation score relate to the awareness and application stages in technology transfer [32], while the association and assimilation stages are captured in the management indicator. While the implementation and management scores represent the operational value and systemic impact of the CP project [16], it was found impractical to properly assess technical impact in this assessment method. For each of these components a compounded 100-point score was developed, reflecting the authors’ broad understanding of key drivers and shapers for effective preventive environmental management in businesses (as supported by in particular [6,13,16,31,45,46]). The scoring system is detailed in Table 1.

This rating scheme was expanded into an interview protocol for a 10–15 minute telephone interview with the senior manager (the CEO, unless unavailable). The choice for a telephone-based instrument was made to minimise response bias, which occurs when respondents answer in a certain direction, i.e. they “consciously or unconsciously misrepresent the truth” [47]. It was anticipated that this response bias would be far more marked in a written survey in which respondents can identify the purpose of the survey and respond to the awareness questions according to what they believe the researcher wants to hear. Moreover, the telephone survey was specifically designed to prevent the respondent from knowing upfront the detailed purpose of the survey and was short enough to make CEOs more amenable to contribute. It started with the implementation questions (which did not refer to environmental issues directly), and then moved into the
management questions (which dealt with environmental management, but not specifically with CP). The specific questions on awareness of the ideas and benefits of CP were only touched upon once a picture had emerged of the company’s efficiency and resource management practices and achievements. Another type of error that may have occurred in the telephone interview was a limited response, due to the CEO being in a hurry or busy when contacting the business. This would skew the results as awareness, implementation or management incentives may be underestimated for that respondent.

5. Trial of assessment method

5.1. Trial design

The trial took place in October and November 2001 and involved: drycleaners; food processors; metal fabricators (including engineering workshops); and printers (including book making). These are dominated by SMEs, and have diverse environmental impacts (energy use, water use and emissions, air emissions and toxic materials). Through the inclusion of drycleaners, a deliberate bias was introduced to create a positive control as the Centre of Excellence in Cleaner Production had worked extensively with this sector to promote CP through performance and process benchmarking [28]. The awareness, management and implementation scores for the drycleaning sector were thus expected to be higher than for the other sectors. The pilot was focused on businesses in the greater Perth region (WA). Half of the respondents for the printing sector were from outside WA (25% Queensland and 25% South Australia) to gain some insight into possible regional differences.

The businesses were randomly sampled from stratified business populations, to ascertain pre-set response levels within each sector and region, respectively: 20 drycleaners; 40 metal fabricators; 40 food processors (all in Perth) and 40 printers (20 in Perth, 10 in Queensland, and 10 in South Australia). Using Yellow Pages® lists were compiled of all businesses within the sector and region, and these were

<table>
<thead>
<tr>
<th>Component</th>
<th>Criteria</th>
<th>Score</th>
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<tbody>
<tr>
<td>Awareness score: awareness of CP ideas and familiarity with their key benefits</td>
<td>Understanding of CP (30 points) Company to provide three features of CP</td>
<td>10 points for each listed feature rated as appropriate by researchers</td>
</tr>
<tr>
<td></td>
<td>Understanding of EE (30 points) Company to provide three features of EE</td>
<td>10 points for each listed feature rated as appropriate by researchers</td>
</tr>
<tr>
<td></td>
<td>Appreciation of possible benefits (40 points) Company to judge four statements on nature of CP/EE</td>
<td>10 points for each appropriate judgement</td>
</tr>
<tr>
<td>Maximum awareness score</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Management score: presence of management incentives conducive to consideration and implementation of CP</td>
<td>Environmental management responsibilities (30 points) Staff with principal environmental management responsibility</td>
<td>Maximum of 20 points, awarded as follows: 8 points for CEO/senior manager, and 3 points for any of engineering/technical manager, environmental manager, EHS officer and other staff</td>
</tr>
<tr>
<td></td>
<td>Environmental management plan (30 points) Presence of a current environmental management plan (regardless of level of formalisation)</td>
<td>5 points for inclusion of environmental issues, and 5 points for inclusion of energy issues</td>
</tr>
<tr>
<td></td>
<td>Staff involvement in development of the environmental management plan</td>
<td>20 points but only awarded if respondent could provide reasonable detail of the plan (e.g. priorities for action and achievements to date)</td>
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<td></td>
<td>Awareness and management of environmental costs (40 points) Maintenance of separate records for costs of gas, fuels, power, water and waste management</td>
<td>Maximum of 10 points. 4 points for each of senior manager, environmental manager and engineering manager. 1 point was awarded for each other staff member. For each item for which costs were tracked, 2 points were awarded, and an additional 3 points if the responding manager was able to provide the respective costs</td>
</tr>
<tr>
<td>Maximum management score</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Implementation score: inclusion of CP or EE elements in innovations implemented by the company in the preceding three years</td>
<td>Recent innovations (50 points) Five projects listed by the company that have been implemented to improve operation’s efficiency</td>
<td>Each project considered to have a CP or EE element was given 10 points</td>
</tr>
<tr>
<td></td>
<td>Recent resource use reductions (50 points) Projects listed in regard to reduction of reduction of water use, reduction of energy use, reduction of liquid waste, reduction of solid waste and reduction of air emissions</td>
<td>Each project with a genuine environmental benefit (over and beyond cost reduction costs) was given 10 points</td>
</tr>
<tr>
<td></td>
<td>Maximum implementation score</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Integrated CP uptake score</td>
<td>100</td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>
organised alphabetic by business name. Next the necessary level of response was ascertained by dividing the target response by the number of businesses. This led the team to define which businesses would be included (in case of food industry for example 40 businesses from a total population of 412, meant every 10th business was selected). In case of non-response (unwillingness to participate) the next one on the list was contacted until a response was obtained.

All participants needed to have between 3 and 250 employees. These numbers were decided upon to prevent exclusion of the micro-operators that could still have a significant impact on the environment. A couple of respondents, however, had only two staff, in addition to the owner/operator working in the business. These were included all the same. One organisation employed over 250 staff but was considered highly innovative and a suitable candidate as a food industry case study.

5.2. Response rates

Of the 334 metal products manufactures in Perth listed in the Yellow Pages®, 149 were contacted and of these, 41 completed the assessment (response rates 27.5%). This was lower than planned probably due to insistence to interview the CEO and because ship/boat builders were particularly busy due to the approaching crayfish season. In the food-related industries, 125 of the 412 listed organisations were contacted, of which 40 CEOs or their representatives were interviewed (32% response rate). Of 106 drycleaners 51 were contacted to obtain the 19 responses (37% response rate). Of these, six had been involved in the sector CP program. Of the over 660 printers and bookbinders in the Perth region, Queensland and South Australia, 40 responses were obtained from contacting 103 companies (39% response, specifically 52% in WA, 29% in QLD and 43% in SA).

The total response rate was 32.7% (428 organisations contacted to obtain response from 140 CEOs, managing directors, owners or equivalents). This was better than the response rate for Holmes and Girardi (16%) [38], for Andrews et al. (29%) [40], but lower than for Zutshi et al. (46%) [41], all mail surveys, in the case of Zutshi only to organisations with high environmental awareness (as they had a certified EMS). Greene [39] and Water and Rivers Commission [44] did not record response rates.

5.3. Cleaner production uptake

Table 2 contains the sector-averaged component and integrated scores. The implementation score is the lowest component score and the management score the highest component score. The average integrated CP score for all businesses surveyed was 27, out of a possible 100. In detail:

- The mean awareness score for all responses is 22. This is consistent with the low level of CP awareness in the Geelong survey (27% of businesses aware of CP) [40]. This trial confirms their finding that much needs to be done to raise awareness levels and convince businesses of the potential benefits of CP.
- The management score was generally the highest of the three component scores investigated. This determined whether the company had an environmental policy or plan, the nature of these, the CEOs awareness of the company’s utility accounts, whether environment or energy conservation were considered in staff evaluation, as well as who is responsible for the environmental affairs of the company. The word responsible created some confusion with most respondents taking it to mean accountable, in which case they may have accrued fewer points if general staff were also considered responsible through their implementation practises. Sixty of 140 businesses indicated that they had environmental policies and/or plans which varied from being an unwritten undertaking to reduce waste, through a written but confidential policy distributed by franchisors or an EPA license, to an extensive plan developed specifically for and by the respondent company. Points were allocated according to the nature of the plan/policy and who devised it. All but one of the organisations kept separate utility accounts and 74 of the respondents (53%) could quote most or all of these from memory or by immediate access through a computer at their desk.
- The lowest scores throughout were for implementation, suggesting that very little innovation is being devised or implemented for conserving resources or reducing waste. Fifty-five respondents (39%) listed at least one innovation that could be ranked as CP. Meanwhile 14 respondents (10%) indicated that they had implemented no innovations during the last three years. Some other innovations listed included retrenching staff and working longer hours, while a few industries indicated that no innovations were

<table>
<thead>
<tr>
<th>Sector (number of responses)</th>
<th>Sector averaged score (scale 1–100)</th>
<th>Integrated CP score</th>
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<tbody>
<tr>
<td></td>
<td>Component averaged score</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Awareness Management Implementation</td>
<td></td>
</tr>
<tr>
<td>Food processing (40)</td>
<td>22 43 20</td>
<td>28</td>
</tr>
<tr>
<td>Metal products (41)</td>
<td>23 41 14</td>
<td>26</td>
</tr>
<tr>
<td>Printing and print finishing (40)</td>
<td>18 39 13</td>
<td>23</td>
</tr>
<tr>
<td>Drycleaning (19)</td>
<td>32 52 27</td>
<td>37</td>
</tr>
<tr>
<td>All sectors (140)</td>
<td>22 43 17</td>
<td>27</td>
</tr>
</tbody>
</table>

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necessary. Respondents were not aware of the environmental and CP focus of the interview until after the implementation questions were asked, allowing the level of their focus on these issues to emerge spontaneously. Overall, this trial derived the score for CP implementation from actual changes made in the companies’ operations, and therefore appears to have found much lower levels of CP implementation than indicated in previous surveys that directly asked companies whether or not they had implemented CP. The trial findings are more consistent with the day-to-day practical experience of CP promoters in Australia, which in turn adds to the argument that previous surveys might indeed have been significantly biased by socially desired rather than factual responses.

In order to analyse the variability of the scores between businesses in the same industry sector, the businesses have been grouped according to their individual scores, in five categories, respectively (similar categories were used before for ranking on environmental reporting [48]):

- **Bottom crawlers**: businesses achieving a score between 0 and 20;
- **Not so hot**: businesses achieving a score between 21 and 40;
- **Pressing hard**: businesses achieving a score between 41 and 60;
- **State of the art**: businesses achieving a score between 61 and 80;
- **Trailblazers**: businesses achieving a score between 81 and 100.

Figs. 1–4 show the frequency distributions for these categories for the component and integrated scores. Although there is a degree of difference between the graphs, it is apparent that overall the share of businesses in the lowest category (bottom crawlers) is remarkably high for the awareness score (54%), the implementation score (70%), and total CP uptake (37%). The exception is for the management score, where 46% of the businesses made it at least to the not so hot category. The conclusion from these frequency distributions is best captured in Fig. 4. This shows that most businesses were bottom crawlers (37%) or not so hot (45%). In other words, 82% of the respondents, achieve an overall score lower than 40 (out of a possible 100) for their level of consideration and implementation of CP. The drycleaners perform better (the two lowest categories contain only 52%). The printing and metal products sectors perform worse than average of the four sectors (in both sectors the two lowest categories account for 90% of businesses).

5.4. Variations by region, sector and business size

The trial was not explicitly structured for an in-depth study of sectoral and regional variations in CP uptake. A statistically significant comparative study would have to include greater numbers of businesses in each of the sectors and regions, and should also investigate whether the regional and sectoral variations are significant variables to be correlated with, for example: size of business; type of operations; and level of environmental legislation, that could have influenced the levels of CP uptake.

The forty companies in the printing and bookbinding sector were from Perth (20 businesses), Queensland (10 businesses in Brisbane, Townsville and Cairns), and South Australia (10 businesses in Adelaide). As there are over 200 companies for each state, the sample size was relatively small but large enough to give an initial indication of possible differences in
the levels of consideration and implementation of CP. Table 3 includes the mean values for the component and integrated scores for each of these states.

Table 3 shows that WA printers and book binders appear to outperform their SA and QLD peers, in particular for implementation, and to a far lesser degree also for management, awareness and CP uptake. A rigorous statistical analysis to confirm this apparent trend was not performed, given the great uncertainty with regard to compounding variables that are potentially quite different between the states (e.g. levels of environmental regulation and waste management costs, business size and structure).

Table 2 shows the sectoral differences. These are statistically insignificant between food processing, metal products and printing industries. The uptake of CP by drycleaners is, however, remarkably higher. The difference of 10 points in the total score between the drycleaners and the average of all sectors is statistically significant. This was expected, given the concerted effort in the preceding 18 months to promote CP to drycleaners. The printers from WA, SA and QLD scored lowest in all three categories. Overall, there is much room for improvement as even the highest scoring sector, drycleaners, achieved only an average of 37 out of a maximum of 100, while the averaged value for all businesses surveyed was 27.

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The 19 drycleaners in this trial included 6 businesses that participated in the sectoral CP/EE program (the researcher undertaking this trial was not aware of which drycleaners had participated). A series of Bonferroni tests were performed to assess the statistical significance of the sectoral differences, and among the drycleaners between participants and non-participants in the CP/EE program. The statistically significant findings are summarised in Table 4. In summary there is a statistically significant difference between drycleaners who participated in the CP/EE program and those that did not participate. The program participants had on average a total score 31 points higher than the non-program participants. Likewise, there is a statistically significant difference between drycleaners who participated in the CP/EE program and all businesses in the other sectors. These participants had on average a total score of 32 points higher than the average of businesses in the other sectors. The analysis also showed that the difference between drycleaners who did not participate in the CP/EE program and businesses in other sectors was not significant. The limited exposure to CP that non-participating drycleaners might have had to CP appears to have had little effect on their CP uptake.

A similar analysis was contemplated for the impact of business size, as illustrated by the distribution of CP uptake scores in Fig. 5. This illustrates in a qualitative way that the larger SMEs outperform the micro SMEs in terms of their environmental performance and consideration and implementation of CP. Using Bonferroni and t-tests, it was apparent that there was no significant difference between large (over 75 employees), medium-sized (16—75 employees), and small (6—15 employees) businesses. Larger companies did, however, outperform micro-enterprises (less than 6 employees) with respect to CP uptake. Given the low numbers of businesses in the larger business size categories, this trial did not provide the proper statistical underpinning for this intuitively justifiable trend.

6. Concluding remarks

Given the inherent conceptual, methodological and fundamental complexities of measuring CP accurately in physical and/or monetary units, the study reported here set out to develop a simplified method to arrive at a proxy indicator for the level of consideration and implementation of CP in particular among SMEs. A review of strengths and weaknesses of different measurement approaches as well as the results of previous environmental management surveys among Australian businesses informed and guided the method development. Merging ideas from technology diffusion and CP impact studies, the proposed semi-quantitative method is based on the

![Fig. 4. Distribution of businesses ranked on their score for CP uptake.](image-url)
notion that successful CP uptake should be demonstrable at the levels of implementation (record of achievement in CP type innovations), management incentives (demonstrable elements of the management and information systems that create a CP-conducive business environment) and awareness (understanding of CP ideas and practices). The indicator was therefore structured in three equally weighted component scores for awareness, management and implementation.

The tool was trialled with 140 businesses from dry-cleaning, printing and book making, food processing and metal fabrication sectors, and took between 5 and 10 minutes to complete for each business. The response rate of 33% compared favourably with response rates from written surveys. The majority of businesses demonstrated low levels of consideration and implementation of CP, as reflected in the averaged CP uptake score of only 27 (out of a potential 100). This is also visible from the distribution of companies between laggards and leaders, which demonstrated that across the four industry sectors, as few as 18% of the businesses achieved an overall CP uptake score of 40 or more (out of a potential 100). These key trial findings align well with the general observations of CP practitioners regarding current levels of CP uptake in SMEs.

The method does still rely upon a certain amount of subjectivity, and therefore lacks precision in assessing the rigour and depth of CP implementation and environmental and economic benefits achieved thereby. The CP uptake score is therefore at best a proxy for the experience and capacity of the business to implement CP. The results achieved by the use of the tool, as in the trial reported here, therefore need to be interpreted with care. They only provide a once-off snap shot of CP implementation across an industry sector. The trial results suggest that the method results in a more realistic picture of the actual industry practice then achieved from written surveys which accuracy and reliability is severely constrained by self-selection, socially-biased answers and low response rates. Although further quantitative verification would be desirable, it is unlikely that the necessary performance data are adequately monitored by SMEs.

**Acknowledgement**

This research was conducted at Curtin University of Technology, with funding support from its Small Grants Scheme, from the Chamber of Commerce and Industry of WA (food and metals sectors), from the Department of Industry, Tourism

**Table 4**

<table>
<thead>
<tr>
<th>(I) Group</th>
<th>(J) Group</th>
<th>Mean difference (I – J)</th>
<th>Standard error</th>
<th>Significant</th>
<th>99% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC in CP program</td>
<td>DC not in CP program</td>
<td>30.99</td>
<td>6.67</td>
<td>Yes</td>
<td>11.07 to 50.91</td>
</tr>
<tr>
<td>Other industry sectors</td>
<td>DC not in CP program</td>
<td>–1.47</td>
<td>3.94</td>
<td>No</td>
<td>–13.25 to 10.31</td>
</tr>
<tr>
<td>Other industry sectors</td>
<td>Other industry sectors</td>
<td>32.46</td>
<td>5.65</td>
<td>Yes</td>
<td>15.58 to 49.34</td>
</tr>
<tr>
<td>Other industry sectors</td>
<td>Other industry sectors</td>
<td>1.47</td>
<td>3.94</td>
<td>No</td>
<td>–13.25 to 10.31</td>
</tr>
</tbody>
</table>

The mean difference is significant at the 0.01 level. DC, dry cleaning; CP, cleaner production. Based on CP uptake score, with maximum of 100 points.
and Resources (printing and book making sector) and from the WA Waste Management and Recycling Fund for the operation of the Centre of Excellence in Cleaner Production. Professor van Berkel held the position of Chair of Cleaner Production, which is proudly sponsored by CSBP Limited.

References