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Journal of Cleaner Production ■■ (2005) ■■■–■■■
Journal of Cleaner Production
www.elsevier.com/locate/jclepro

Encouraging industry to assess and implement cleaner production measures

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Abstract

Cleaner production stakeholders have a strong desire for industry to consider cleaner production opportunities in their facilities and once they are assessed, to follow through on their implementation. This paper examines local and international initiatives within the Canadian stakeholder community (including government, NGOs, consultants, industry) that contribute to the initiation and implementation of cleaner production in industry. Specifically, stakeholders have consciously drafted regulatory compliance, education, co-funding incentives, and development-based cleaner production programs. As illustrated by case studies from six industries, the programs work together to create a climate favorable for implementation of cleaner production concepts and approaches. Based on the cleaner production drivers and barriers identified by research, the programs are well designed. However, as with cleaner production itself, there is always room for further improvement. Specifically: (i) regulatory compliance programs and timetables should leave room for cleaner production (versus end-of-pipe) approaches; (ii) cleaner production co-funding programs should target small and medium-sized enterprises (SME) and require them to use a multimedia approach (air, water, waste); (iii) education programs should incorporate demonstration assessments, feasibility assessments of common recommendations, and follow-up communication to foster implementation and continuous improvement; and (iv) mandated cleaner production should include absolute (i.e. waste/tonne production) rather than relative standards (i.e. X% reduction from status quo) in order to avoid penalizing historically proactive corporations.

Keywords: Cleaner production; Implementation; Regulatory climate; Incentive programs; Sustainable development; Aerospace; Automotive; Wine; Textile; Wood industry; Coffee; Dairy; Regulation; Incentive

1. Introduction

Cleaner production can generate short- and long-term environmental and social improvements, well beyond those possible with regulatory compliance programs. It can also improve the competitiveness of industry by increasing revenues and decreasing non-product output. Therefore, industry, government, non-government organizations (NGOs), consultants and the general public (i.e. stakeholders) all have a vested interest in the assessment and implementation of cleaner production measures by industry.

Research has helped to identify the barriers and drivers for the adoption of cleaner production by industry. In recent years, the Canadian stakeholder community has initiated regulatory compliance, education, incentives, and international development programs to encourage industry to assess and implement cleaner production.

This paper briefly outlines relevant research and describes regulatory and incentive programs for cleaner production. It then uses case studies to illustrate how

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doi:10.1016/j.jclepro.2005.07.013

these programs have served to promote cleaner production, in Canada and abroad, in the following industrial sectors:

1. An aerospace contractor
2. An automotive supplier
3. A textile mill
4. A coffee and dairy cooperative
5. In sugar mills
6. The wine industry
7. The wood processing industry [1]

Finally, the paper offers observations on strengths of the existing programs and highlights areas for improvement based on the case study results.

2. Research into drivers and barriers to adoption of cleaner production

The seemingly obvious advantages to industry of cleaner production (waste reduction, cost savings, improved compliance, process efficiency, and reduced liability) often are not sufficient for fostering rapid adoption of cleaner production practices. The Illinois Waste Management and Research Center's ADOP^{2}T program has assessed reasons for slow P2 adoption rates and outlined methods to address knowledge gaps (principle, awareness and how-to knowledge) and hence to accelerate diffusion of P2 technologies [2].

In the metal finishing sector, 65% of the ADOP^{2}T program's recommendations have been implemented to date and an additional 23% are still being considered. They attribute their success to a customer-driven, sector-based approach that addresses problems at a root cause level and is based on innovation diffusion principles. Essentially, innovative diffusion principles refers to technology demonstrations to increase interest, pilot trials to reduce uncertainty, and case study champions to lead by example.

The Toronto Region Sustainability Program (TRSP) found that companies participated in their program based on seven drivers [3]. In decreasing order, the drivers were: regulatory mandated P2, co-funding programs, desire for stewardship, environmental compliance issues, risk reduction, resource conservation, and improved efficiency.

However, when it comes to implementation, TRSP found that three drivers were most prevalent: risk reduction, corporate image, and economics/cost (in decreasing order). It is interesting to note that industry ranked these drivers differently than many consultants and governmental legislators projected that they would.

Social marketing research has been used to identify barriers and design tools for promoting the adoption of cleaner production. According to research by McKenzie-Mohr Associates [4], barriers can be uncovered with a review of relevant articles and reports, focus groups, and by direct observation.

They recommend the use of tools for behavior change such as:

- obtaining introductory commitments prior to larger requests;
- providing reminder prompts in appropriate locations;
- development of community social norms (peer pressure);
- credible and appropriate communication; and
- providing incentives.

However, the behavior change tools must be used in the context of removing the specific barriers identified during the assessment.

3. Regulatory drivers for cleaner production

In recent years, regulatory stakeholders in Canada's three levels of government (Federal, Provincial and Municipal/Regional) have consciously drafted regulations to promote cleaner production (also referred to as pollution prevention). Generally, these regulations have reflected the specific priorities of the regulating body.

3.1. Federal regulatory drivers

The Canadian Council of Ministers of the Environment (CCME) defines pollution prevention as the use of processes, practices, materials, products, substances or energy that avoid or minimize the creation of pollutants and wastes, at the source.

Environment Canada has a legal obligation to manage the risks associated with the use and release of substances declared to be toxic under the Canadian Environmental Protection Act, 1999 (CEPA). According to the act, Environment Canada can use Pollution Prevention (among other tools) to manage the risks associated with toxic substances. Several notices have been drafted under CEPA specifically requiring companies to develop and to implement Pollution Prevention plans.

Environment Canada also administers the National Pollutant Release Inventory (NPRI) which requires industrial users and consumers of chemicals above certain volume thresholds to annually report on the fate of these compounds, and to provide information about cleaner production measures that have been implemented at the facility that are designed to reduce the use and release of these and other polluting substances.

3.2. Provincial regulatory drivers

Provincial regulatory drivers primarily take the form of increasingly strict discharge criteria and cleanup criteria for water, air and land. Also, increasingly onerous reporting requirements for hazardous waste shipments, discharges to surface water and air emissions tend to increase the economic driving forces for cleaner production.

For example, substantial discharges of solvents to the atmosphere in Ontario are now required to be reported under both the National Pollutant Release Inventory (NPRI) and Provincial Regulation 127. Preparation of these reports provides an ongoing administrative cost that can potentially be avoided through cleaner production.

3.3. Municipal/regional regulatory drivers

Municipal and regional bylaws in Canada vary considerably. Metropolitan Toronto is a forerunner in the incorporation of cleaner production into a municipal bylaw. Toronto City council recently passed a very proactive sewer use bylaw [5]. Chapter 681 of the bylaw mandates that industries and commercial institutions discharging any amount of 27 subject pollutants are required to prepare pollution prevention plans. The bylaw also includes timetables and significant penalties (such as CN$5000 per day for not preparing a P2 plan).

The Toronto bylaw has been quite successful, with a high level of compliance by targeted industries. Among other things, the bylaw required dental facilities to install advanced amalgam separators. As reported by the Naval Institute for Dental and Biomedical Research, this measure has already reduced the mercury content in Toronto's sewage sludge by 58% [6]. The Toronto bylaw's specific inclusion of pollution prevention is likely to generate further Hg reductions through continuous improvement efforts.

Other municipalities/regions are considering adding P2 requirements to their bylaws. Many are also lowering their discharge limits. As illustrated in the first case study presented in Section 5, the Region of Halton's new lower limits for volatile organic compounds was a primary driver for the owner's implementation of cleaner production measures at their facility.

4. Incentive programs to encourage cleaner production

4.1. Regional programs

The Toronto Region Sustainability Program (TRSP), administered by the Ontario Center for Environmental Technology Advancement (OCETA), is a partnership between Environment Canada, the Ontario Ministry of the Environment and the City of Toronto. It provides matching funds (up to CN$4000) for small and medium-sized enterprises (SMEs) to complete multimedia P2 assessments. The assessments are performed by consultants of the industry's choosing from a roster pre-screened for relevant experience. Case studies are available on OCETA's website (http://www.oceta.on.ca/TORSUS/studies.htm).

Enviroclub is a partnership of Environment Canada, Canada Economic Development, and National Research Council Canada [7]. In the province of Quebec, Enviroclub organizes groups of about 15 small and medium-sized companies from a given region or sector. Industry participants are required to pay a registration fee (CN$2500) for which they receive 4 days of workshops and subsequently, 90 hours of professional services to help them to identify and carry out pollution prevention projects (CN$8100 value). Case studies are available on Enviroclub's website (http://www.enviroclub.ca).

The Eco-Efficiency Business Assistance Program was a pilot program administered by the Eco-Efficiency Center in Nova Scotia. The program was a cost sharing arrangement with the program contributing 75% (up to CN$6000) and the company contributing the remaining 25%. The program involved three steps: an initial review by the program staff (no cost), an opportunity assessment by a qualified consultant (value up to CN$2000) and an implementation plan/feasibility assessment by the consultant (value up to CN$6000). The program commenced on July 1, 2003 and 15 companies had signed on to participate in the pilot program by December 2004. Case studies are available on the Eco-Efficiency Center's website (http://www.dal.ca/eco-efficiency). Based on the success of the pilot-program, The Eco-Efficiency Center is seeking funding for an ongoing program.

4.2. Federal programs

Since Canada has signed the Kyoto accord, it has a strong commitment to reducing greenhouse gas (GHG) emissions. National Resources Canada (NRCan) has an Energy Innovators program designed to help industry reduce energy consumption (http://www.nrcan.gc.ca). The program provides matching funds (up to CN$5000) for an energy efficiency assessment of a facility. In the author's experience at a cheese factory and a wine factory, this program combines well with other cleaner production initiatives to decrease the environmental footprint and increase financial returns for investments in energy efficiency improvements.

5. Case studies of industries implementing cleaner production

An industry's decision to assess and implement cleaner production measures is frequently based on a variety of factors. However, there is often a deciding factor. The case studies outlined below were selected to illustrate various implementation drivers.

5.1. Proactive conscience driven cleaner production: Cape Canaveral and Kennedy Space Center

The United Space Alliance (USA) operates facilities at the Kennedy Space Center and Cape Canaveral to refurbish the Space Shuttle's solid rocket boosters (SRBs) and prepare them for reuse (formerly operated by Pratt and Whitney). They have a corporate commitment to continuously reduce their three largest waste streams. Once these waste streams are reduced, other streams enter the top three and hence become the subjects of assessment.

To assist them in these continuous improvement efforts, the author was invited to assess three facilities associated with refurbishing the SRBs (see Fig. 1).

(1) In the Thrust Vector Control (TVC) clean room, component parts from the SRB engines and parachute cones are individually cleaned in a series of dip tanks. Cleaner production measures were identified to reduce rinsewater consumption and tank evaporation, and to recycle bath solutions. With the incorporation of Pratt and Whitney's facilities into those of USA, other waste streams have become more significant. However, when the TVC clean room measures are implemented, they are projected to reduce water consumption and waste generation in the TVC clean room by about two thirds.

(2) Biological growth in the refurbishment facility's cooling towers was controlled with an ozone generator and supplemented with chlorine addition. Cleaner production assessment found that cooling the ozone generator with chilled water could increase its effective output by about 30% (due to the solubility curve for ozone). This in turn could eliminate the need for supplemental chlorine. The resulting decrease in chloride accumulation would reduce the volume of blowdown necessary to manage the accumulation of dissolved solids in the cooling water.

(3) The SRB robotic hydrolasing facility uses high-pressure water (17,500 psi) to remove ablative coating from the surface of the SRB sections. The facility had set an objective to recycle 100% of this water. The author designed, pilot tested and helped commission a series of filtration, adsorption, ion exchange, neutralization, and ozonation facilities that are now recycling 100% of the water used in this process.

5.2. Regional bylaw driven cleaner production: Trimac Transportation

Trimac Transportation operates a facility in Oakville, Ontario, Canada, that cleans stainless steel semi-bulk paint containers (totes) and portable mix tanks for reuse by the automotive industry (see Fig. 2). The vessels are cleaned with water, chemicals and solvents. Specifically, a toxic solvent, methylene chloride (also known as dichloromethane), was being used to remove the adhesive left behind by numerous labels on the totes and for various touch-up work.

The facility was faced with multiple legislative drivers. The most pressing (deciding) driver was a recent amendment to the Region of Halton's sewer use bylaw. Among other things, the amendment added discharge limits for specific solvents (including 2 mg/L for methylene chloride).

Fig. 1. Proactive cleaner production at Cape Canaveral enables the United Space Alliance to recycle 100% of the water used to pressure clean the Space Shuttle's solid rocket boosters.

Fig. 2. Trimac has eliminated 100% (24 tonnes/year) of methylene chloride use by changing to a baking soda and compressed air blasting process.

However, additional regulatory drivers were on the horizon. Specifically, Environment Canada recently published a notice requiring significant consumers of methylene chloride to prepare cleaner production plans. Also, the Ontario Ministry of the Environment recently reduced the air discharge Point of Impingement (POI) limit for methylene chloride from 5.3 milligrams to 0.66 milligrams per cubic meter.

Annual National Pollutant Release Inventory (NPRI) and Ontario Regulation 127 air emission reporting for methylene chloride also consumed time and resources.

The Toronto Region Sustainability Program (TRSP) recently expanded its catchment area to include Oakville. Under this program, Trimac received matching funds (CN$4000) to complete a multimedia cleaner production assessment. The assessment was performed by a combined team of Trimac and Enviro-Stewards staff.

Following a brief training session, the cleaner production team assessed Trimac's resource-consuming and waste-generating processes and operations. Due to regulatory drivers and health and safety concerns, cleaner production measures for methylene chloride were given the highest priority during implementation.

The team selected a compressed air and baking soda blasting process as an alternative to methylene chloride. Pilot testing (see Fig. 2) confirmed that the process could achieve equal or better product quality.

Superficially, this process appeared to be more expensive than the methylene chloride-based process. However, when compared to the cost of treating the facility's effluent to meet Halton's new discharge limits and meeting the Ministry of the Environment's new air quality criteria, the process saved about CN$162,000 per year. Workers report more pleasant working conditions and the process reduced Trimac's annual methylene chloride consumption below reporting thresholds for NPRI and Regulation 127 (as of March 28, 2005, the facility is 100% free of methylene chloride).

The facility flushes residual paint to a roll-off container located outside the plant. It is expensive to dispose of the water and paint mixture in this tank. The tank also requires heating (to avoid freezing) and presents a spill hazard. Alternatively, the P2 assessment found that residual paint can be recovered from the totes with a vacuum system.

By source segregation, compatible paints can be vacuumed directly into appropriate drums. In the short term, cost savings associated with avoiding disposal of paint contaminated water can finance the project. In the longer term, reuse alternatives for the segregated paint can be investigated.

Solvents are used in the valve room for cleaning and reassembling the valves removed from the base of the totes. In the short term, the team found that off-site recycling would be economical relative to hazardous waste disposal costs. In the longer term, improved ultrasonic cleaning processes are being investigated to eliminate volatile solvent use.

When implementation is complete, the cleaner production measures are projected to reduce methylene chloride emissions by 24 tonnes/year, hazardous wastes by 55 tonnes/year, water consumption by 810 m^3/year, and greenhouse gas emissions by 2 tonnes/year. The measures have an aggregate payback of 5 months, relative to compliance relying solely on end-of-pipe treatment. A case study for this project (http://www.oceta.on.ca/TORSUS/Trimac.pdf) is available on OCETA's website.

5.3. Education driven cleaner production: Ontario's wine industry

Wineries consume a large quantity of water and energy. They reportedly consume about 26.5 liters of water per (9 litre) case of wine bottled [8].

Wine and juice are acidic (pH 3 to 4) and have high biochemical oxygen demands (about 225,000 mg/L BOD_5). Therefore, product losses can lead to municipal sewer damage (due to low pH) and sewer surcharges due to BOD_5 concentrations that are higher than domestic sewage.

Although product conserved through cleaner production has a substantial value (CN$1 to 2/L), Ontario's wine industry has been slow to adopt cleaner production.

The author completed economics-driven and conscience-driven cleaner production assessments at five mid- and large-size wineries. Cleaner production measures at one of the larger facilities achieved a 30% reduction in water consumption, a 6% increase in wine yield and a 30% decrease in the time required to chill the wine product (by insulating the tanks). In addition, Enviro-Stewards and Enermodal helped Stratus Vineyards, a producer of ultra-premium wines, to become the first Leadership in Environment and Energy Design (LEED™) certified winemaking facility in the world. Stratus is also the first building of any kind certified under the Canadian Green Building Council's LEED™ New Construction program.

In order to encourage a greater proportion of wineries to consider cleaner production, Environment Canada retained Enviro-Stewards to develop and present a concise and practical pollution prevention (cleaner production) guide and workshop. A workshop, based on the guide, was presented at Brock University on November 26, 2004. The workshop was designed to provide winery staff with the tools and examples necessary to complete cleaner production assessments at their facilities. According to the Wine Council of Ontario (a co-sponsor of the workshop), attendees at the workshop accounted for more than 95% of Ontario's wine production.

Based on positive feedback from the workshop, Brock University's Cool Climate and Oenology Institute (CCOVI) intends to re-offer the workshop as part of its continuing education program (early 2006). Also, the Winery Association of Nova Scotia and Environment Canada have retained Enviro-Stewards to complete demonstration assessments and workshops for Atlantic wineries and breweries.

5.4. Federally mandated cleaner production: textile industry

Much of Canada's textile industry has shifted to countries with lower wages and fewer, or less rigorously enforced, environmental controls. The remaining mills tend to manufacture bulky or specialty textiles. Enviro-Stewards is presently working with a Canadian manufacturer of carpets to reduce pollutant generation and the potential for spills, at source.

The deciding factor for this mill in commencing cleaner production assessment was a notice published in December 2004 under the Canadian Environmental Protection Act, 1999. The notice requires wet processing textile mills to prepare pollution prevention (cleaner production) plans. Specifically, the facilities must provide a plan to achieve 97% reduction of nonyl phenol and its ethoxylates (NPEs) relative to 1998 consumption figures. NPEs are commonly used in detergents, emulsifiers, wetting agents and dispersing agents. They are listed as CEPA toxic compounds due their hormone-mimicking behavior.

The notice also requires the mill's combined effluent to pass a toxicity test. The Microtox test specified uses luminescent bacteria. If 13% wastewater (by volume) is sufficient to cause a 50% decrease in light output from the bacteria, the wastewater is considered to be toxic.

The textile mill agreed to proactively assess their facility and prepare their P2 plan before the CEPA notice was promulgated. This proactivity allowed them to be included in a specific incentive program that is presently coming to the end of it's funding period.

The assessment work and P2 planning were recently completed at the mill. The combined team of textile mill and Enviro-Stewards staff identified products such as a spin-finish oil used at the facility that contained NPEs. Suitable alternatives to these products are being investigated and implemented.

The team also identified the primary processes and operations that contribute to the toxicity of the mill's combined effluent:

- spin-finish oils;
- carpet backing;
- unused dye solutions.

Spin-finish oils are used to coat threads in order to improve their handling characteristics. When these oils are removed in a subsequent water scouring process, they add to the toxicity of the wastewater. The carpet backing which also passes through the scouring process also contributes to effluent toxicity. The team is presently working with the spin-finish oil and carpet-backing vendors to investigate less toxic alternatives, and are examining the scouring process to investigate recycling and oil recovery opportunities.

Dye solutions are typically prepared in mix tanks and transferred to dying vessels. Due to physical limitations of the existing facilities, there is often a minimum volume of dye solution that can be prepared. Any unused dye solution is discharged to the sanitary sewer. The team redesigned the mixing processes to allow preparation of any size of batch.

5.5. Development driven cleaner production

As illustrated by the impact on the Canadian textile industry (see Section 5.3), the social, environmental and economic sustainability of the Developing World is in the long-term best interests of Canadian cleaner production stakeholders. Cleaner production is an excellent approach in developing countries where waste water is typically discharged without any treatment at all. End-of-pipe treatment is beyond the financial capacity of many industries in the developing world. However, cleaner production actually reduces their costs [9].

The Canadian stakeholder community conscientiously provides opportunities for developing countries to benefit from cleaner production knowledge developed in Canada. For example, The Canadian International Development Agency (CIDA) is helping to train Laotian industry to implement cleaner production. OCETA and Enviro-Stewards prepared and presented a training seminar for Laos' wood industry in January 2004.

At the start of the workshop, the representatives had very little understanding of the environmental impact of their operations. For example, used paint thinner (solvent) was normally poured onto the ground and hence contaminated drinking water supplies. Through discussion groups, the participants from industries in this emerging economy came to understand how industries can work together to economically solve environmental problems. For example, a collective solvent still, for reclaiming and recycling the paint thinner, would quickly pay for itself in terms of avoided solvent purchases. OCETA is presently assessing the economic potential of a solvent still and other cleaner production alternatives.

Similarly, following severe earthquakes in 2001, Enviro-Stewards' president and a draftsman were in El Salvador helping to rebuild homes. The damaged homes were located on a coffee and dairy cooperative. In response to a request from the community leaders, they examined the cooperative's coffee and dairy operations and helped them to develop a sustainable development plan.

Essential details of the plan are as follows:

Environmentally,

- reuse coffee fruit pulp as cattle feed,
- reuse pre-treated wastewater for irrigation; and
- compost organic waste and wastewater sediment for soil conditioning.

Socially,

- provide good wages, community fields, libraries, schools, clinics, nutritional programs and business start up loans.

Economically,

- brand products (based on quality and sustainability) to secure a fair price and diversification into other products to weather market fluctuations.

6. Strengths and areas for improvement of existing programs

As indicated by the research and case studies, the deciding factor triggering specific industrial facilities to commence assessment and implementation of cleaner production vary considerably. However, in many cases various regulation, education, incentive and development programs initiated by the stakeholder community provided a supportive atmosphere for the decision to pursue cleaner production.

6.1. Proactive conscience and economics driven cleaner production

These assessments tend to produce excellent results. Unfortunately, there are relatively few clients with the size, environmental consciousness and sophistication necessary to pursue these projects on their own. In the absence of these conditions, other programs are helpful in promoting cleaner production.

6.2. Regulatorily driven cleaner production

As illustrated by the dental amalgam separators required by Toronto's new sewer use bylaw [5,6], mandating of specific cleaner production measures can generate a high level of compliance and produce substantial environmental benefits (58% decrease in sewage sludge mercury). However, this approach is only practical if sufficient assessment work has been completed to ensure that the waste stream targeted is the primary contributor and the cleaner production measure specified is practical and economically feasible.

Municipal/regionally mandated preparation of cleaner production plans (such as the Toronto sewer bylaw) can achieve a high level of compliance. However, if the compliant industries view this merely as a paper exercise, they will receive relatively little economic benefit. Also, the environment and working conditions (human health) will not significantly improve. Based on the case studies, incentives and educational programs can help industries to view the regulatory requirements as an opportunity to improve their processes.

Stricter municipal/regional sewer use bylaw discharge limits can provide strong driving forces for cleaner production. However, the compliance program components of most bylaws are typically based on end-of-pipe treatment models. Specifically, compliance timetables allow time for standard engineering tasks (characterization, design, construction, commissioning) but no time is allowed for in-plant cleaner production measures.

There is a common myth that environmental improvement through cleaner production takes longer than end-of-pipe approaches. However, in the Trimac case study, implementation of in-plant cleaner production measures allowed for a reduction in methylene chloride of 99% within 6 months and complete elimination of methylene chloride within 1 year. A traditional end-of-pipe would have taken longer to construct the treatment facilities and would likely never achieve 100% reduction.

Provincial regulatory drivers in Canada such as stricter air discharge limits can also provide driving forces for cleaner production. However, care should be taken to coordinate with other legislation to prevent shifts of contaminants to other media (such as sewer discharge). Care should also be taken to avoid classification of industries that reuse by-products from another facility as hazardous waste treatment facilities (due to the negative public perception and cost implications associated with this terminology).

Federally mandated cleaner production plans can be more effective and less time consuming than drafting and passing regulations for specific toxic compounds or specific industrial sectors. However, care must be taken to ensure that cleaner production targets specified are reasonable and achievable. For example, the relative NPE target in the textile case study (97% reduction relative to 1998 consumption) unintentionally penalizes industries who operated efficiently prior to 1998 relative to firms who were less conscientious. In such cases, an absolute standard (such as kg/tonne of production) would be more appropriate than a relative standard (such as % reduction from status quo).

The effluent toxicity test in the textile case study has the strength that it avoids the loophole of changes from a legislated toxic compound to an equally toxic but not yet legislated compound. However, without an accompanying water consumption correction factor (m^3 of water per tonne of product), the criteria can unintentionally reward those industries that use water inefficiently (and hence dilute their wastewater).

6.3. Incentive driven cleaner production

Even in the presence of regulatory drivers, incentive programs can be used to encourage industries to expand the scope and depth of cleaner production assessments. Incentive programs are also excellent prompts for industries to commence cleaner production at a specific moment in time. Some programs also feature information sharing and peer support networks (such as Enviroclub) that can foster long-term commitments to cleaner production. In the author's experience, such training and collaborative approaches tend to increase the proportion of recommendations implemented and the likelihood of continuous improvement.

However, care must be taken in the drafting of incentive programs such that the interests of all stakeholders are adequately addressed. For example, certain programs can be so focused on achieving the funding agency's objectives that there is relatively little incentive for industries to participate. Other programs can be so prescriptive and budget restrictive that there is little flexibility for the consultant to develop innovative solutions.

Finally, social marketing research indicates that removal of incentives can undermine internal motivations for engaging in an activity [4]. As illustrated by the conscience and economics driven case studies, cleaner production has significant rewards for proactively participating industries. However, overly generous incentive programs could potentially generate a culture of dependence in which industries no longer desire to participate without an incentive program.

6.4. Education and development driven cleaner production

As illustrated by the Ontario wine industry case study, education-based programs can encourage the bulk of an industry to catch up to the early adopters of cleaner production. Results of follow-up with Ontario wineries were presented at the 9th Canadian Pollution Prevention Roundtable in Victoria, British Columbia (http://www.c2p2online.com/documents/2005CPPR-Bruce_Taylor.pdf). The Laos and El Salvador case studies indicate that cleaner production is likely the best hope for substantial environmental improvements in developing countries that presently discharge their waste with no treatment at all [9].

However, to be successful, the principle- and awareness-based cleaner production training needs to be followed through with how-to based training [2]. Specifically, in the Laos example, the original scope was limited to a 2-day training workshop. In-plant demonstration assessments at two or more facilities and a pilot-scale test of a solvent reclamation still would substantially improve the industrial group's knowledge base and their ongoing commitment to cleaner production. In the case of the El Salvador coffee and dairy cooperative, field trials of coffee fruit based feed for cows, organic solids composting, and wastewater reuse for irrigation are necessary to address practical difficulties and demonstrate sustainability. However, coordinating and funding such support for follow-up work in developing countries can be very challenging.

7. Conclusion

The Canadian stakeholder community has consciously drafted regulatory compliance, education, co-funding incentive, and development-based cleaner production programs. As illustrated by the case studies, the programs work together to create a climate that is favorable for implementation of cleaner production. Depending on each industry's specific priorities and circumstances, any of the programs may become the deciding factor in an industry's decision to adopt cleaner production.

In general, the programs are well designed, based on the cleaner production drivers and barriers identified by the research. They are also successful in exporting this knowledge to assist developing countries. However, as with cleaner production itself, there is always room for further improvement. Specifically:

- As illustrated in the Trimac case study (Section 5.2), regulatory compliance programs and timetables should leave room for cleaner production (versus end-of-pipe) approaches.
- Cleaner production co-funding programs (Section 4) should target small- and medium-sized enterprises (SME) who often have difficulty justifying the initial assessment. Such co-funded assessments should consider a multimedia approach (air, water, waste) to encourage more robust recommendations.
- As illustrated in the Winery, Laos and El Salvador case studies (Sections 5.3 and 5.5), education programs should incorporate demonstration assessments, feasibility assessment of common recommendations and follow-up communication with participants, in order to foster cleaner production implementation and continuous improvement.
- Any mandated cleaner production (Section 5.4), should use absolute (i.e. waste/tonne production) rather than relative standards (i.e. X% reduction from status quo) in order to avoid penalizing historically proactive corporations and rewarding laggards.

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