Measuring Eco-efficiency in Business:

Feasibility of a Core Set of Indicators

National Round Table on the Environment and the Economy

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Mandate

The National Round Table on the Environment and the Economy (NRTEE) was created to "play the role of catalyst in identifying, explaining and promoting, in all sectors of Canadian society and in all regions of Canada, principles and practices of sustainable development." Specifically, the agency identifies issues that have both environmental and economic implications, explores these implications, and attempts to identify actions that will balance economic prosperity with environmental preservation.

At the heart of the NRTEE's work is a commitment to improve the quality of economic and environmental policy development by providing decision makers with the information they need to make reasoned choices on a sustainable future for Canada. The agency seeks to carry out its mandate by:

- advising decision makers and opinion leaders on the best way to integrate environmental and economic considerations into decision making;
- actively seeking input from stakeholders with a vested interest in any particular issue and providing a neutral meeting ground where they can work to resolve issues and overcome barriers to sustainable development;
- analyzing environmental and economic facts to identify changes that will enhance sustainability in Canada; and
- using the products of research, analysis and national consultation to come to a conclusion on the state of the debate on the environment and the economy.

The NRTEE has established a process whereby stakeholders themselves define the environment/economy interface within issues, determine areas of consensus and identify the reasons for disagreement in other areas. The multistakholder approach, combined with impartiality and neutrality, are the hallmarks of the NRTEE's activities. NRTEE publications address pressing issues that have both environmental and economic implications and which have the potential for advancing sustainable development.

Members of the National Round Table on the Environment and the Economy

The NRTEE is composed of a Chair and up to 24 distinguished Canadians. These individuals are appointed by the Prime Minister as opinion leaders representing a variety of regions and sectors of Canadian society including business, labour, academia, environmental organizations, and First Nations. Members of the NRTEE meet as a round table four times a year to review and discuss the ongoing work of the agency, set priorities, and initiate new activities.

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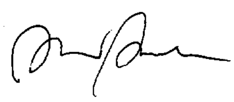
Preface

Company managers and directors know that it is good business to reduce waste, minimize energy use and avoid the costs and liabilities of dealing with the dispersion of pollutants. These three goals constitute three tenets of the concept of "eco-efficiency" as formulated by the World Business Council for Sustainable Development (WBCSD). Yet information about these goals is almost never reported in a standardized manner that would allow useful dialogue and permit easy comparison between divisions, time periods, companies and business sectors. Not only company managers and directors but also external audiences — investors, customers, regulators and the public — lack standardized information by which to compare company achievements regarding the above-mentioned goals.

In an effort to remedy this situation, the National Round Table on the Environment and Economy (NRTEE), in cooperation with the WBCSD, set out to create standardized indicators for business reporting. Despite the fact that human patterns of consumption may be the planet's largest threat, it is still essential to encourage cleaner and more efficient production practices.

For the past two years, a number of volunteer companies have gone to considerable trouble and expense to work together in this project in order to hammer out the indicators and decision rules that would make sense in the real world of competitive business. They have achieved some important successes, but much remains to be done. As representatives of the NRTEE, we express, on behalf of all our colleagues and staff, our sincere gratitude to the firms and individuals whose work in this project has advanced a worthwhile cause.

Finally, it is important that the crucial contributions of Alan Willis, Glenna Ford, Jim Fava, Kevin Brady and Elizabeth Atkinson be recognized. Without their efforts, the work could not have proceeded as smoothly and as effectively as it did.



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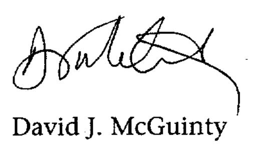

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Executive Summary

Feasibility Study — Key Results

Canada's National Round Table on the Environment and the Economy (NRTEE), with the cooperation of the World Business Council for Sustainable Development, and the active participation of eight companies,[1] has carried out a feasibility study on indicators for energy and material intensity. This has yielded many practical lessons and insights of value to those who develop and implement eco-efficiency indicators. Indicators for energy intensity — energy consumed per unit of output — have been found to be readily and widely applicable and meaningful. Indicators for material intensity — materials consumed per unit of output — have also been found to be feasible, but are more relevant in some industry sectors than others. Practical issues concerning implementation and interpretation have been identified for both energy and material intensity indicators. The stage is set for broader testing and demonstration of these indicators.

In addition, options for pollutant dispersion indicators were evaluated at a pre-feasibility study stage. The companies made valuable progress toward the selection of a suite of issues-related pollutant dispersion indicators that would be meaningful, widely applicable and scientifically acceptable. Many practical considerations were identified as to the design, use and interpretation of such indicators. Feasibility testing of selected components from a set of pollutant dispersion indicators would be a useful next step.

Eco-efficiency — Context for the Study

The NRTEE's goal for this study was to explore the feasibility of designing and implementing meaningful and robust indicators for three of the elements of eco-efficiency.[2] In setting this goal, the NRTEE recognized that eco-efficiency is a practical approach that businesses are adopting in setting and achieving their environmental performance objectives. The development of ways to measure and report eco-efficiency is therefore an important aspect of the evolution of this approach.

Eco-efficiency indicators should be reliable signposts and triggers for dialogue and further enquiry. They should not be expected to measure and communicate all aspects and details of environmental performance, whether at the corporate, division, facility or product level. Other indicators and data, such as absolute quantities, or communication of the particular context may also be necessary. Eco-efficiency indicators when

1. The participating companies were 3M Canada, Alcan Aluminium, Bell Canada, Monsanto, Noranda, Nortel Networks, Procter & Gamble, and Pacific Northern Gas (representing WestCoast Energy).
2. According to the definition developed by the World Business Council for Sustainable Development. See NRTEE, *Backgrounder: Measuring Eco-efficiency in Business* (Ottawa, 1997).

combined with other information should assist company managers, their boards of directors and external stakeholders in tracking progress toward environmental performance targets. These indicators should facilitate comparison of performance between companies and across sectors. Care must be taken to avoid selecting indicators that are ambiguous or may lead to adverse results in other aspects of eco-efficiency.

The study approached indicator design in a flexible manner by selecting a few minimum indicators and including some complementary ones where more complete information was required. Testing and evaluation of the indicators focused on their technical feasibility (such as the required degree of precision and availability of data, the clarity of decision rules, definitions and compilation procedures) and on interpretation issues (the meaning that may be ascribed to the indicators by users).

Energy Intensity Indicators

For energy intensity, the minimum indicator tested was energy consumed from all sources within the manufacturing or service delivery process (numerator, reported in joules) per unit of manufactured output or service delivery (denominator, reported in physical, operational or financial terms). Financial denominators tested included sales revenues and value-added formulas. Because of the fluctuations that occur in monetary values over time through inflation and exchange rates, the study participants concluded that indicators that use financial denominators should be accompanied by related indicators that use physical/operational denominators as well.

Numerators for the seven complementary indicators agreed upon were:

- energy delivered and consumed, including energy consumed in energy delivery;
- energy delivered and consumed, including energy consumed in energy delivery, plus fleet energy;
- energy consumed during the use phase of a product's life;
- energy inherent in materials used in manufacture or service delivery, and in acquiring and processing those materials;
- energy consumed in the end-of-life phase of a product's life-cycle (i.e., in disposal);
- energy consumed or generated during the entire life-cycle; and
- greenhouse gas (GHG) emissions related to energy consumption as measured for one or more of these indicators.

The level of testing for these indicators (e.g., site, product, business unit, total company) varied from company to company.

Several practical considerations came to light in compiling and testing both the minimum and complementary indicators. Two particular issues are allocation of data between products and data availability. Allocation issues were sometimes encountered at lower levels of aggregation where, for instance, several products are manufactured at a particular site or facility. Adequate data about the electricity grid supply (for carrying out conversions to joules) were difficult to obtain in some locations, especially for the complementary indicators. Energy generated during production (including co-generation of electricity), and as a by-product, was another topic requiring further consideration in indicator design.

GHG emissions attributable to energy use may not be the full measure of a company's GHG emissions (which may also be measured and reported under the pollutant dispersion indicator set). Further, the usefulness of a company calculating and reporting upstream GHG emissions, if these are also being measured and reported by energy and raw materials suppliers, may be limited to performing product comparisons and evaluating product design decisions.

Material Intensity Indicators

The participating companies tested two minimum indicators for material intensity and one complementary indicator. The first minimum indicator compares total mass (weight) of materials used directly in the product and co-product with the total output of product and co-product (measured in physical, operational or financial terms, as done with the energy intensity indicator). The second minimum indicator includes total indirect material in the numerator (indirect materials being those used in production but not included in the final product). Packaging material included with the product and co-product is regarded as a material for these indicators.

Ideally, the material intensity indicator should measure material consumed per unit of function or service, but such a measurement appears to be too difficult at this time. Instead, material consumed per unit of output was used as the basis for indicator design. The two minimum indicators are therefore intended to focus on reducing material requirements to deliver physical products for consumption. The indicators address "gate to gate" material consumption, not that of upstream or downstream life-cycle stages. The indicators are relevant to waste minimization (and therefore to cost savings) as well as to resource conservation objectives.

The complementary indicator tested by two companies compares total mass (weight) of materials and packaging recovered, recycled and reused with the total output of product and co-product. This indicator addresses further aspects of waste minimization and resource productivity.

The companies' work yielded many insights, of which four are particularly important. First, a material intensity indicator is not really relevant or meaningful for extractive industries, such as mining, or for service industries, such as telecommunications carriers. The companies also concluded that primary and secondary manufacturing industries are likely to find more use for material intensity indicators than are product assembly, formulation and packaging industries.

Second, changes in product mix can result in a material intensity indicator that does not reflect improvements in material intensity at the plant or overall company level.

Third, caution needs to be exercised in industries where the use of large masses or volumes of one particular substance, such as a gas or a solvent, may overwhelm the indicator.

Fourth, and related to the previous issue, is the effect of water (which may be transformed to another state but rarely destroyed). Where water is included in the product, it should not normally be included in the calculation of the indicator, either as an input or an output. Where water is used for non-contact cooling or heating purposes, it should be omitted as a material (although its condition or quality after use may need to be addressed, perhaps under pollutant dispersion indicators). However, a separate water consumption indicator may be needed when water is included in products or used in production, if that water is taken from and not returned to a location where water scarcity is a concern (e.g., a particular aquifer, an arid country, etc.).

Pollutant Dispersion Indicators

Aggregation of data about different substances with different characteristics and effects is the primary problem in designing indicators for dispersion of toxic and other non-product outputs classified as pollutants.

Pre-feasibility study work on the pollutant dispersion indicators concluded that these must address a wide range of public concerns that cannot be reduced to a single indicator. The most useful and workable approach was seen as the selection and design of indicators relative to issues or categories of common concern. These categories may, for example, be smog precursors or atmospheric ozone depletors, GHG emissions, or dispersion of "priority toxics" in water.

Where the science is sufficiently advanced to allow meaningful weightings to be applied, aggregation of substances within specific issues (such as GHG or ozone-depletion issues) may be appropriate. A useful next step would therefore be for a cross-section of companies to design and test indicators for a few selected issues, such as GHG emissions (for which data are generally readily available), smog precursors and atmospheric ozone depletion.

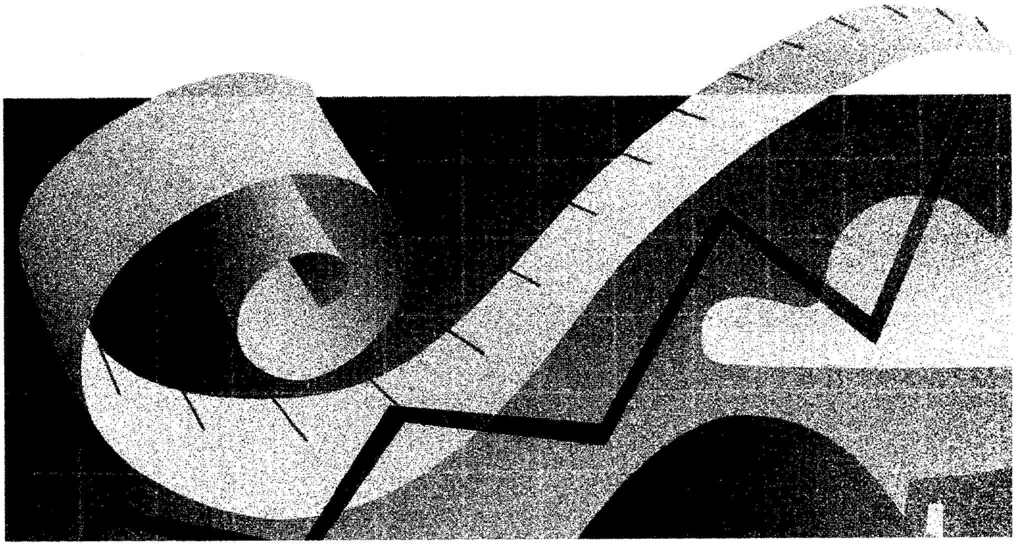
Early in the feasibility study, attempts were made to design a single indicator for toxic dispersion. This would have been based on aggregating specific toxic substances included in recognized lists such as the Toxic Release Inventory (TRI) in the United States and the National Pollutant Release Inventory (NPRI) in Canada. Companies already measure and report data about releases of these toxics to the environment. For this approach, consideration was given to weighting methods, such as the categories in Canada's Accelerated Reduction/Elimination of Toxics (ARET) program, for substances to be included in overall and complementary indicators. The study concluded, however, that such an approach would only be workable and acceptable when there is sufficient international consensus on substances to be monitored and on weightings that reflect relative hazard and toxicity. Such consensus is needed to permit meaningful aggregation into a small number of indicators.

Three important issues for pollutant dispersion indicators were identified. First, there is a need for them to be both scientifically acceptable and meaningful to users. Second, while an eco-efficiency type of indicator will relate pollutant dispersion to product output or value added, many users will likely want absolute measurement data about environmental releases as well, regardless of improvements in release per unit of output. Third, indicator design and decision rules need to distinguish clearly between non-product outputs that are released directly to the environment as pollutants, and those that may or may not eventually result in releases, depending on management and disposal practices.

Future Directions

The key to progress for eco-efficiency indicators is active, phased experimentation and shared learning among companies to discover which eco-efficiency indicators are the most appropriate, meaningful and cost-effective to produce.

To move forward and build upon the lessons learned from this project, the NRTEE encourages continued evaluation by the participating companies and testing by a wider group of companies, particularly in the manufacturing sector. More research is needed regarding pollutant dispersion indicators. Industry associations may be able to play a useful role in promoting testing and research.



1. Introduction

1.1 Key Accomplishments

How feasible are eco-efficiency indicators that companies can use to measure energy and material intensity? What are the possible future directions for development of eco-efficiency indicators for pollutant dispersion? Canada's National Round Table on the Environment and the Economy (NRTEE) has reached empirical conclusions on both these issues.

Specifically, the design and testing of core indicators (i.e., a small number of cross-cutting indicators) for energy and material intensity by eight companies under the auspices of the NRTEE has provided the following results. Indicators for energy intensity — energy consumed per unit of output — were found to be readily and widely applicable and meaningful. Indicators for material intensity — materials consumed per unit of output — were also found to be feasible, but are more applicable and relevant in some industry sectors than others. This feasibility work also yielded many practical lessons and insights of value to those who are developing and implementing energy and materials intensity and other eco-efficiency indicators.

Options for pollutant dispersion indicators were evaluated at a pre-feasibility study stage. The participating companies made valuable progress toward the selection of a suite of issues-related pollutant dispersion indicators that would, after further research, design and testing, be meaningful, widely applicable and scientifically acceptable. Their work revealed many practical considerations as to the technical feasibility, use and interpretation of such a suite of indicators. Moreover, the study produced agreement that no single aggregate indicator would be adequate to measure and report all aspects of pollutant dispersion in any meaningful way, and that focusing only on toxic releases is not adequate to address the wider range of pollutant dispersion issues related to non-product outputs.

The study results are just a beginning. Ultimately, all companies will have to undertake systematic processes of practical testing and evaluation to determine:

- which indicators are most useful to them;
- what data and resources are needed to compile the indicators;
- how to interpret and apply indicators at different levels within the company;
- how and where to report indicators; and
- how to assess the indicators' benefits against the costs of producing them.

The process used to conduct the feasibility study of the energy intensity and material intensity indicators was found to be a useful model for future work in evaluating proposed indicators. As well, it had beneficial side effects for the participating companies (see box on page 7).

1.2 Report Structure

The remainder of this introduction summarizes the process leading to this study and the criteria used to guide indicator selection. Chapters 2 and 3 of this report set out the results of the feasibility testing process for energy and material intensity indicators respectively. Chapter 4 outlines the results of considering indicators for pollutant dispersion. The final chapter summarizes the overall conclusions, the lessons learned and proposed future directions arising from the work completed on the three indicators.

Appendix A provides a tabular overview of the companies that volunteered for the exploratory work described in this report, highlighting their experiences in carrying it out. Appendix B describes the original proposals for toxic release indicators and what was learned in considering them for possible feasibility testing. Appendix C presents a chronology of the workshops held during the study and identifies the related workshop reports available from the NRTEE.

1.3 Proposed Eco-efficiency Indicators

In 1996, the NRTEE established its Eco-efficiency program to explore, in cooperation with the World Business Council for Sustainable Development (WBCSD), the possibility of developing a core set of indicators for companies to use in measuring eco-efficiency. These indicators would be designed to encourage and help companies set measurable eco-efficiency targets, assist in assessing their progress and performance against these targets, and facilitate comparisons and benchmarking of environmental performance between companies of all sizes and types, as well as within sectors.[1]

In deciding to proceed with this work, the NRTEE recognized eco-efficiency indicators as a practical tool that is useful to business and external users in:

- setting and achieving environmental performance objectives; and
- developing ways to measure and report eco-efficiency.

Such indicators are thus an important element in the evolution and implementation of eco-efficiency.

The NRTEE adopted the definition and elements of eco-efficiency as developed under the auspices of the WBCSD:

Eco-efficiency is reached by 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.[2]

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1. The NRTEE's proposals for indicators are discussed more fully in NRTEE, *Backgrounder: Measuring Eco-efficiency in Business* (Ottawa, 1997).
2. World Business Council for Sustainable Development, *Eco-Efficient Leadership for Improved Economic and Environmental Performance* (Geneva, 1996), p. 4.

The WBCSD went on to expand this definition, setting out seven elements of eco-efficiency:

- reducing the material requirements for goods and services;
- reducing the energy intensity of goods and services;
- reducing toxic dispersion;
- enhancing material recyclability;
- maximizing sustainable use of renewable resources;
- extending product durability; and
- increasing the service intensity of goods and services.

Regarding "value generation," the WBCSD noted:

A key feature of eco-efficiency is that it harnesses the business concept of creating value and links it with environmental concerns. The goal is to create value for society, and for the company, by doing more with less over a life-cycle.

From the outset, the goal of the NRTEE was to devise a core set of indicators. This would consist of a few robust, widely accepted and understood, quantifiable and verifiable indicators that all companies could use — both for internal purposes and for external performance reporting. (The intent was not, however, to bring about new, mandatory external disclosure requirements.) Eco-efficiency indicators should therefore be reliable signposts and triggers for dialogue and further enquiry.

In the view of the NRTEE, eco-efficiency indicators should not be expected to measure and communicate all aspects and details of environmental performance, whether at the corporate, division, facility or product level. Other indicators and data such as absolute quantities may also be necessary. Reporting any single eco-efficiency indicator alone is unlikely to be useful and could be misleading. Explanatory notes about the content and meaning of indicators (similar in purpose to the notes to financial statements) may also be necessary to ensure they are fully and clearly understood.

The NRTEE recognized that the credibility of eco-efficiency indicators in general for communicating with external audiences is an important issue, because it relates to needs for third-party verification as well as transparency in reporting and indicator design. In this regard, the scope and boundaries of an indicator and the level of aggregation are important considerations, since high levels of aggregation may mask important trends or provide less meaningful information. Similarly, life-cycle data may include too many assumptions or estimates at a product level.

The three eco-efficiency indicators originally put forward by the NRTEE as a starting point for informed, focused discussion and possible testing were as follows.

Resource Productivity Index

This indicator was designed to express as a percentage the material and energy contained in a company's products, by-products and usable wastes compared with the materials and energy consumed in their production.

Product and Disposal Cost to Durability Ratio

This indicator, intended to address life-cycle product stewardship and recyclability, was designed to divide the cost of producing a product (expressed in terms of purchase price) plus the cost of its ultimate disposal by the number of years of its useful lifetime.

Toxic Release Indicator

This indicator was designed to express as a single number the amount of toxic materials released during a period (or in manufacturing a particular product). This number was calculated as the sum of the masses of each toxic substance released adjusted by their respective toxicity weighting factors, compared with the product output during the period.

Key issues included the technical feasibility of a given indicator, its usefulness and meaning to various users, and the cost-effectiveness for a company in producing it.

1.4 Washington Workshop

These proposals were discussed in detail at an international workshop sponsored by the NRTEE in conjunction with the WBCSD in Washington, D.C., in April 1997.[3] The wide cross-section of expert participants from business and other stakeholder groups at the workshop reached the following conclusions.

Resource Productivity Index

It would be more useful and meaningful, as well as more practical and feasible, to develop separate indicators to address material intensity and energy intensity. These could be tested first on a pilot basis with a few volunteer companies, then later (based on the pilot results) with a larger cross-section of companies.

Product and Disposal Cost to Durability Ratio

Such an indicator would be difficult to design and apply because it attempts to combine too many concepts that are difficult to define and measure, both physically and in monetary terms, and thus would be of questionable relevance and understandability. Workshop participants considered the proposed indicator unworkable; however, they acknowledged it might be worthwhile at some point to consider and perhaps develop one or more indicators to address matters such as product durability, material recyclability, or lifetime cost compared with years of life.

Toxic Release Indicator

As proposed, this would be difficult to implement because of lack of consensus, primarily scientific, over which substances to include in the measurement and over their relative toxicity. Such a lack of consensus would inhibit the meaningful aggregation of data about different substances. Workshop participants agreed, however, that it was

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3. The Washington workshop proceedings and conclusions are detailed in NRTEE, *Backgrounder: Measuring Eco-efficiency in Business* (Ottawa, 1997).

important to address the need for an indicator for toxic (later broadened to pollutant) dispersion. As well, they noted that requirements for toxic release reporting to regulators are already in place in some countries. An appropriate indicator would facilitate assessment of performance improvement over time and aid comparison between companies.

Participants therefore recommended that work continue to define indicator scope and substances for inclusion, to consider alternative approaches for dealing with relative toxicity, and to consider how best to build on existing reporting schemes that companies are already using to track and record data. This work might eventually provide a basis for useful field trials by companies.

Other Conclusions

Workshop participants agreed on a number of characteristics and criteria for useful, acceptable eco-efficiency indicators. The indicators should:

- provide a concise, aggregated view of performance;
- be capable of integration with other measures;
- link with financial measures and be relevant in capital markets;
- be relevant to business strategy;
- be widely applicable across industry sectors;
- be relevant to and implementable by small and medium-sized enterprises;
- be relevant and implementable in other countries;
- support decisions and lead to action;
- be relevant for periodic environmental reports;
- be applicable to non-renewable resource sector industries;
- be scientifically acceptable and credible;
- focus initially on internal, not external, users' needs;
- recognize the public policy and social implications of reporting on performance; and
- be independently verifiable, if necessary.

Work on indicator design and testing should recognize that:

- development and implementation of eco-efficiency indicators would necessarily be a voluntary and evolutionary process;
- eco-efficiency is a subset of sustainable development, and that linkages with socio-economic issues must therefore always be appreciated;
- there have to be trade-offs between simplicity and completeness, and that it is important to move ahead even with imperfect measures, since they can be refined over time;

- eco-efficiency indicators are tools for evaluation of progress and for decision making, not targets or goals for improvement; and
- development of indicators for all measurable elements of eco-efficiency would be desirable, but perverse results should be avoided, even if this means not having indicators for certain elements.

Specific technical challenges for indicator design were noted:

- product-related indicators — what aspects of a product's total life-cycle to address in indicators, and what level of aggregation to use — product, product line, division or company;
- aggregation — how to avoid masking important information that may be lost or submerged in aggregation, and how to avoid distortions through applying subjective weighting schemes to aggregate data;
- weighting, normalization and indices — when and how to normalize indicators, when and how to create indices, and how to avoid subjectivity in weighting schemes; and
- financial as well as physical measures — whether to use financial as well as physical measures in indicator design, recognizing the inherent limitations of financial accounting and reporting practices.

1.5 Feasibility Study — The Process

Following the Washington workshop the NRTEE identified eight companies willing to design and carry out feasibility tests of material and energy intensity indicators, and to explore further the issues and possibilities for a toxic dispersion indicator. Participating in the study were 3M Canada, Alcan Aluminium, Bell Canada, Monsanto, Noranda, Nortel Networks, Procter & Gamble, and Pacific Northern Gas (representing WestCoast Energy). In addition, Stelco Inc. and Dow Chemical Co. participated in discussions about toxic and pollutant dispersion indicators.

Initial planning meetings of company representatives and invited experts took place in November 1997 (for the material and energy indicators) and January 1998 (for the pollutant dispersion indicator). An interim progress review meeting attended by the participating companies and the NRTEE was held in March 1998. At the same time, a forum was convened to inform interested participants of initial results. A workshop attended by study participants was subsequently held in June 1998 to share and summarize findings and issues arising from the work on all three types of indicators. Finally, a meeting was held in October 1998 to give input on a draft report about the study. Detailed technical reports from the various planning meetings and workshops were important to the continuity of the process.[4]

4. Available upon request from the NRTEE. Refer to Appendix C for a chronology of the workshops.

At the outset, the companies and expert participants established the following four criteria to guide the process of selecting and evaluating indicators for the feasibility study:

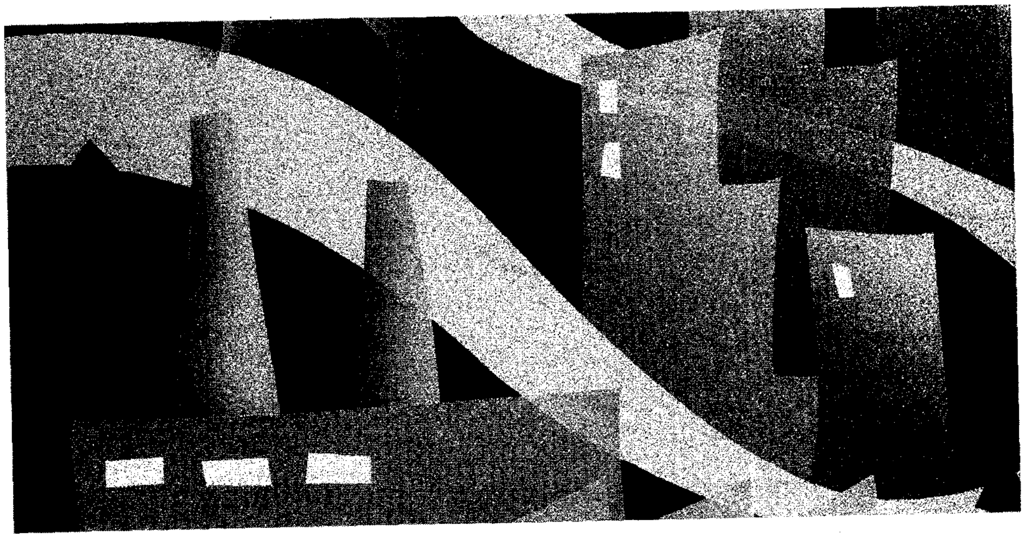
1. **Robust, non-perverse** — eco-efficiency indicators must be robust information sources for improvement, that is, they must be clear, unambiguous and representative regardless of context. An essential corollary is that the use of these indicators should not result in reduced eco-efficiency or increased environmental impacts elsewhere in the system.
2. **Rules for inclusion/exclusion** — principles, rules and guidance are needed for the transparent inclusion and exclusion of data, measurements and assumptions used to derive indicators.
3. **Cost-effective data collection** — the data and measurements for the indicators should either be available or obtainable in a cost-effective manner.
4. **Usefulness as a management or corporate reporting tool** — the indicators should be applicable and useful at several levels within the company, including at the business unit, regional and corporate levels.

Experience with all three types of indicators and the conclusions reached for each confirmed the importance and soundness of these criteria. The energy and material intensity indicators substantially satisfy these criteria; for the pollutant dispersion indicator, the criteria will continue to serve as important guidelines in a longer developmental process.

The Study Process: Benefits and Lessons Learned

The process:

- is reproducible in terms of definitions, boundaries and general decision rules and study approach;
- has provided the methodological guidance that will be required in the future;
- has simplified the concept of eco-efficiency for some of the participants;
- is leading to indicators that could serve various audiences;
- has provided simplified, reasonably uniform measures of how production is being managed;
- facilitates informed dialogue with audiences by providing indicators that show trends;
- has the potential to lead to a consistent, uniform approach to measuring eco-efficiency among major companies;
- is a practical way to move toward a manageable number, not a laundry list, of eco-efficiency indicators;
- has introduced participants to new expertise both within and external to the study; and
- has exposed participants to broader international perspectives on indicator development and use.



2. Energy Intensity Indicators

2.1 Indicator Set, Lessons Learned

The energy intensity indicator is an eco-efficiency indicator that has broad applicability. It is technically feasible and meaningful to audiences both within and outside companies. Unlike materials, which vary widely, energy is like a common currency unit in all businesses and countries. The development and implementation of indicators to measure the energy intensity of a company's products and services therefore proved to be both a realistic and worthwhile endeavour. However, further theoretical and practical work is needed to fully address greenhouse gas (GHG) emissions as part of a set of indicators for energy intensity.

The Energy Intensity Indicator Set

The eight participating companies agreed on a minimum energy intensity indicator that would be tested by all the companies. This indicator is given in Figure 2.3 below. The participating companies also identified a suite of seven other energy indicators from which companies might choose one or more to test in order to provide a more complete picture of their energy use.

Figure 2.1

The Minimum Energy Intensity Indicator

$$\frac{\text{Energy consumed by the company}}{\text{Unit of output (product or service)}}$$

Energy was defined as total energy consumed, measured in joules, to manufacture a defined unit of output or deliver a defined service. Energy included all forms of energy from all sources within the manufacturing or service delivery process, including energy generated internally (e.g., waste oil to heat) during product manufacture or service delivery. Fuels were converted from mass to joules through the use of accepted conversion factors.

Unit of output is a measure, in either physical/operational terms (e.g., mass, units of product or service) or financial terms (e.g., sales revenues, value added), of manufactured output (products and co-products, whether sold or inventoried) or service delivered. Financial denominators tested included sales revenues and value-added formulas. Because of the fluctuations that occur in monetary values due to inflation and exchange rates, the expert participants and company representatives concluded that indicators that use financial denominators should be accompanied by indicators that use physical or operational denominators.

Figure 2.2

The Complementary Energy Intensity Indicator Set

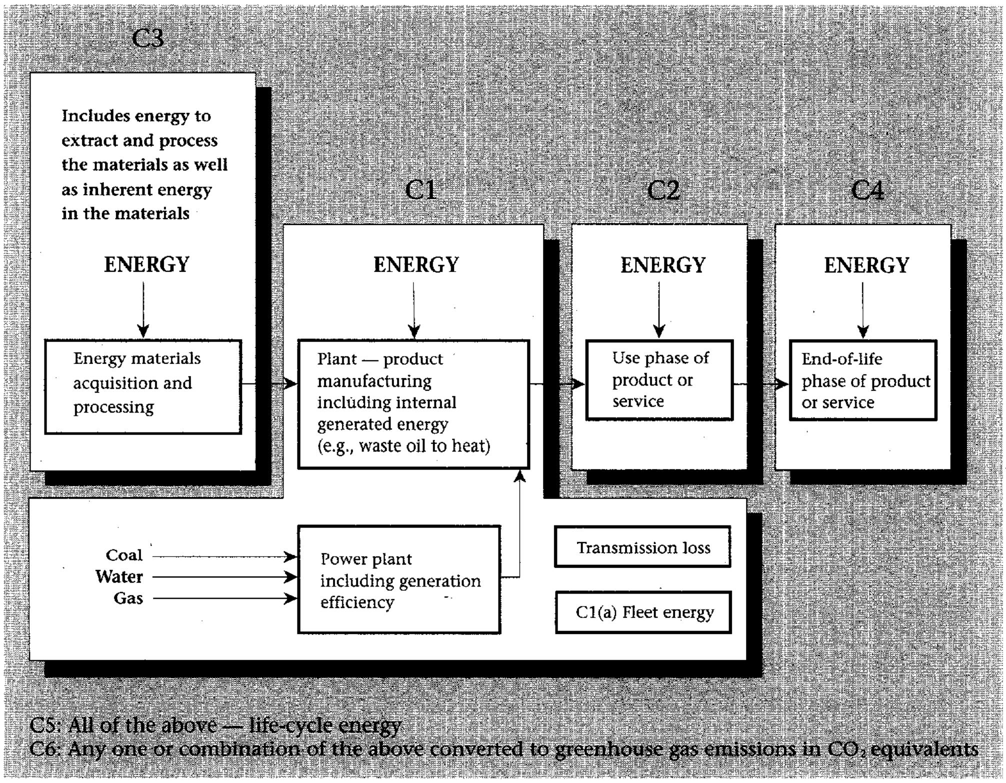
- C1: "expanded energy" consumed by the company per unit of output, defined as the total amount of energy (electric and non-electric), including energy delivered to or generated within the plant or service entity, plus the energy consumed by energy delivery (losses during production/generation and distribution). Conversion data from the National Energy Reliability Council would be used to calculate energy consumed by energy delivery.
- C1a: "expanded energy" as in C1, plus fleet energy, namely the energy consumed by fleets transporting products or services to their intended markets.
- C2: energy consumed during the use phase of a product's life-cycle.
- C3: energy inherent in the materials used in manufacturing a product, and energy consumed in the acquisition and processing of materials entering the manufacturing process or service entity.
- C4: energy consumed and/or generated in the end-of-life phase of a product's life-cycle, that is, in disposal.
- C5: life-cycle energy, that is, the energy consumed during the entire life-cycle of a product. These indicators are shown schematically in Figure 2.3.
- C6: energy-related GHG emissions — the GHG emissions associated with each of the energy types and sources measured under any of the above complementary indicators or the minimum indicator above.[5]

Companies' selections of complementary indicators for use in the feasibility study took various factors into account. These included 1) the relevance of the indicators to the companies' eco-efficiency improvement objectives (which might focus on, for example, manufacturing process energy); 2) the life-cycle energy use profile of products (which may be more energy-intensive in the use phase than during the manufacturing phase); and 3) the users of the indicator within the company or outside it.

5. Participants were referred to J.T. Houghton, L.G. Meira Filho, J. Bruce, Hoesung Lee, B.A. Callander, E. Haites, N. Harris and K. Maskell (eds.), *Climate Change 1994: Radiative Forcing of Climate Change and an Evaluation of the IPCC IS92 Emission Scenarios* (Cambridge, U.K.: Cambridge University Press, 1994) (ISBN: 0-521-55962-6) for information on the global warming potential of GHG emissions; and to Canada, *Canada's Second National Report on Climate Change: Actions to Meet Commitments Under the United Nations Framework Convention on Climate Change* (Ottawa: Environment Canada, 1997) and A.P. Jaques, *Canada's Greenhouse Gas Emissions: Estimates for 1990*, Environmental Protection Series Report EPS 5/AP/4 (Ottawa: Environment Canada, 1992) for emissions factors related to the various energy carriers.

Figure 2.3

Schematic of Full Complementary Indicator Set for Energy Intensity



Lessons Learned

Several practical considerations came to light during testing of the minimum and complementary indicators.[6] For example, adequate data about the electricity grid supply were difficult to obtain in some locations for carrying out conversions to joules, especially for the complementary indicators. As well, problems with energy allocation were sometimes encountered where, for example, several products were being manufactured at a particular site or facility. Other topics requiring further consideration included the effect of changes in product mix for higher levels of aggregate indicators, and the treatment of energy generated during production, including co-generation.

With respect to GHG emissions, such emissions attributable to energy use are not necessarily the full measure of a company's GHG emissions, since there may also be process-related emissions (which the company may measure and report under the pollutant dispersion indicator set described in Chapter 4 of this report). The value of calculating and reporting upstream GHG emissions may be limited to performing product comparisons and evaluating design decisions, since these emissions may be reported by upstream companies.

6. These are discussed later under "Technical feasibility issues."

2.2 Decision Rules and Definitions

Decision/Accounting Rules for the Indicators

Participating companies agreed to use the same decision/accounting rules for the minimum indicator, but allowed themselves greater flexibility in developing the complementary set.[7] For the minimum energy indicator, energy units were to be joules, energy allocations (if needed for normalization to a product) were to be based on output masses, and time periods covered were to be selected (and reported) by each company. For any complementary indicators selected, companies were to document and report their decision rules as to the types of energy included/excluded, assumptions and conversion factors used, and calculation procedures.

Definitions

For the purposes of applying the decision/accounting rules and for precision and consistency in data collection for the feasibility study, the various types of energy to be considered were defined as follows:

Fossil energy: Energy derived from any fossil source of carbonaceous material, including oil, coal and natural gas.

Non-fossil energy: Energy derived from any non-fossil source, including hydroelectric, geothermal, nuclear, wood and others.

Process energy: Energy input (electric and non-electric) required to operate process equipment.

Feedstock energy: Energy that is fuel-related inherent energy or the energy content of material resources. Feedstock energy was to be calculated as the gross calorific value (high heat) of the energy resources removed from the earth's energy reserves and used in producing input materials consumed in the company's operating processes. Feedstock energies were to be calculated separately for each material input.

Transport energy: Energy required to transport intermediate or final products to the next point of use, as well as the energy required to transport waste materials for final disposition.

Total energy: The sum of process, transport and feedstock energy flows as well as any related pre-combustion energy. Pre-combustion energy is the energy that is expended to extract, process/refine and deliver a usable fuel for combustion; pre-combustion energy values were to be included for all fuels used within the scope of an indicator.

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7. Additional background and technical detail for the study may be found in the four workshop reports prepared during the course of the study and available on request from the NRTEE.

Data Collection and Quality Rules

Each company was responsible for its own data collection and handling, and for describing and documenting the data collection and calculation procedures used. As well, each company had to decide on the scope of the indicators (e.g., company, facility, product, product line). The level of testing for the indicators (e.g., site, product, business unit, company) therefore varied from company to company, based on individual circumstances and requirements.

Companies were to report on the source, nature and quality of their data, as well as provide estimates of variability. They would indicate whether their data were primary, secondary or surrogate and whether they were measured, calculated or estimated. Both qualitative (consistency, representativeness, anomalies and missing data) and quantitative (completeness and precision) data quality indicators could be used. Participants were also encouraged to document their costs and the business benefits of conducting the pilot test. In this way, the study was designed to complement existing measurement and management systems, rather than to require the creation of new ones.

Regarding purchased electricity, information from the electricity grids for the various operating sites of a company was to be used. The conversion of the electrical power mix into joules needs to take into account the combustion efficiencies of the various fuels consumed in energy production, the conversion efficiencies of the generating facilities and the transmission efficiencies related to line losses.

2.3 Technical Feasibility Issues

Technical feasibility issues for the energy intensity indicator set identified by participating companies related to three main areas: availability of data (including information about electricity supply), allocation procedures and changing product mix. Procter & Gamble also identified the need to look at energy accounting rules for co-generation, life-cycle stages and transportation data. Other companies encountered practical difficulties in advancing the feasibility study due, for example, to unforeseen changes in business priorities, corporate re-structuring or plant expansion.

Availability of data: Difficulties were noted in obtaining energy supply data (profiles) for the various types of energy. Some companies believed that determining the actual source of electrical energy obtained from grids might be difficult in some countries and regions, but noted that this type of data is becoming increasingly available.

Allocation procedures: The choice between alternative allocation approaches could cause problems for comparability between companies, where, for example, different metals are being extracted from ore and different approaches are used to allocate energy to different product outputs. In some cases, a mass-based allocation might be appropriate; in others, an economic-based allocation might be more appropriate. Further, a pilot study at a site or product level could cause allocation problems that would not occur at higher levels of aggregation, such as when developing an indicator at the business unit or company-wide levels. In this regard, Noranda, for which energy is a fairly significant operating cost, had difficulty allocating energy to different streams in its site processes. Higher level aggregate indicators, however, may be affected by other factors, as noted below under "Use and interpretation issues."

Changing product mix: New and discontinued products and product lines posed a challenge for developing consistent, comparable indicators. Both Procter & Gamble and 3M experienced misleading results when their product mixes were altered — these changes sometimes masked environmental performance improvements.

Table 2.1 summarizes participants' decisions regarding energy intensity indicators for the purposes of the feasibility study.

Energy Intensity and Greenhouse Gas Emissions

One technical issue of particular relevance for the participants related to GHG emissions. GHG emissions may arise from production processes and delivery of services, and at different stages in product life-cycles. The proposal for complementary indicator C6, which targeted energy-related GHG emissions (through the use of conversion factors for different types of energy source), linked energy consumption and intensity with the broader issue of global climate change. The pollutant dispersion indicator suite may also include indicators related to atmospheric releases of GHGs.

The eco-efficiency definition and components do not directly address climate change due to GHG emissions. Nonetheless, energy intensity is clearly relevant to this issue when energy is consumed from sources that cause GHG emissions. The question arises, therefore, of how energy intensity indicators can be designed to communicate meaningfully about GHGs associated with a company's products and services, whether on a "gate to gate" process-related basis or from a life-cycle perspective, both upstream and downstream. This issue requires consideration as does the issue of how indicators for energy-related and process-related GHG emissions would fit within a suite of pollutant dispersion indicators to give a complete and clear picture of a company's GHG emissions.

Table 2.1

Energy Intensity Indicator Selection and Results Summary

Company	Minimum indicator — denominator chosen	Complementary indicator(s)	Level/scope	Time frame; data quality indicators
3M	Unit of output	C1a — expanded energy plus fleet energy per unit of output C5 — life-cycle energy per unit of output C6 — energy-related GHG emissions	Manufacturing site	One year; not chosen
Alcan	Unit of output	C5 — life-cycle energy per unit of output C6 — energy-related GHG emissions	Site & possibly products	One year/ completeness & representativeness
Bell	Indicator chosen: kWh/m^2	Not tested	Building	One year; not chosen
Monsanto	Unit of revenue — value added, e.g., sales revenue less cost of raw material	Not chosen	Company for minimum set, product line for complementary	One year; expert review
Noranda	Unit of output	Not tested	Site (changed from product)	Completeness & representativeness
Nortel Networks	Unit of revenue — cost of sales	C6 — energy-related GHG emissions	Company	One year; not chosen
Procter & Gamble	Unit of output (internal measure called statistical case)	C1 — expanded energy consumed by the company per unit of output C1a — expanded energy plus fleet energy per unit of output C2 — energy consumed during product use phase	Various levels — company, business unit and product line	Varies; completeness & representativeness
WestCoast Energy/ Pacific Northern Gas	Unit of output	Data not available	Data not available	One year; not chosen

2.4 Use and Interpretation Issues

A third area of focus for the feasibility study was the overall utility of the indicators and their interpretation by users. The indicators proved to be valuable at several levels within companies, including at the business unit, regional and corporate levels.

Study participants recognized the need to interpret the energy indicators meaningfully, since these indicators can be applied to many different situations (e.g., to reflect energy use at buildings that serve many different purposes and whose characteristics vary widely). The following issues relating to the interpretation of and meaning to be ascribed to the indicators were identified.

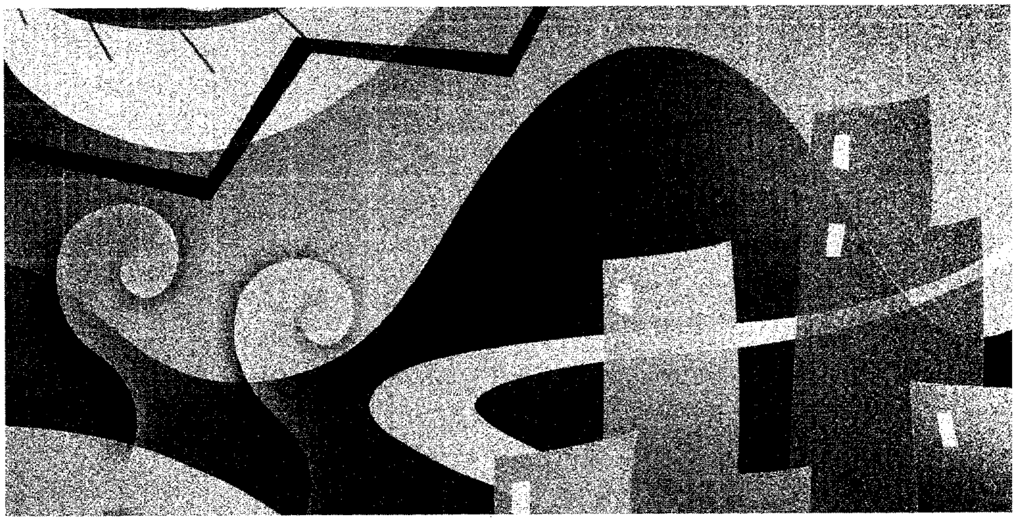
Highly aggregated indicators: Study participants expressed concern about loss of meaning, at least for internal users and possibly for external users, when data are aggregated across product lines or sites. In some situations, highly aggregated indicators can lead to oversimplified results.

Complementary indicators — the suite: Study participants saw the need for more than one energy intensity indicator, in addition to the minimum as proposed or C1, expanded energy. They favoured C6 (energy-related GHG emissions), although, as noted above, it may not provide the full GHG picture for a company and may not necessarily be formulated as an eco-efficiency indicator unless normalized by an appropriate denominator. Also, further consideration should be given to using energy indicators only in conjunction with materials and pollutant dispersion indicators in order to obtain a more complete picture and minimize the possibility of wrong conclusions or perverse results.

Standardization of numerator: Further work is required to reach consensus on selecting the numerator and on defining its scope and boundaries, and on how much flexibility to allow companies while still maintaining comparability between companies and sectors. The availability of data for electricity grids and sources and the general acceptability of conversion factors are important considerations in deciding what is reasonable to expect in numerators. This issue is closely related to the issue of how many energy intensity indicators are needed — just one or a suite?

Standardization of denominator: Study participants agreed that standardization of the numerator is important; however, they considered that greater flexibility is acceptable, even necessary, in selecting the denominator for the indicator. The participants preferred financial or value-related denominators, especially at the company level, but both unit output and unit value denominators need further consideration as to their appropriateness in various sectors.

Proprietary issues: Some study participants expressed concern that the use of financial denominators in the indicators might disclose proprietary, confidential and/or competitive information.



3. Material Intensity Indicators

3.1 Indicator Set, Lessons Learned

The study participants concluded that an indicator of material intensity is a reasonable and workable measure of eco-efficiency. However, it is more applicable and relevant in some industry sectors, such as manufacturing, than in others, such as mining and ore extraction, or product assembly, formulation and packaging. Companies encountered greater challenges in developing and implementing the material intensity indicator set than they did with the energy indicators. For example, unlike the energy indicators (which resemble a currency that can be converted to common units), the indicator set for material intensity necessarily encompasses a large number of different materials, each with its own physical attributes and purpose. For example, one kilogram of waste paper is vastly different from one kilogram of waste metal.

The Material Intensity Indicator Set

The study participants agreed to test the following three material intensity indicators — two as the minimum set for measurement, and the third as the complementary or optional indicator that would allow companies to build on the minimum set to provide a more complete picture of their performance.

Ideally, the material intensity indicator should measure material consumed per unit of function or service, but such a measurement appears too difficult at this time. Instead, material consumed per unit of output became the basis for indicator design. The two minimum indicators are therefore intended to focus on reducing material requirements to deliver physical products for consumption. The indicators address "gate to gate" material consumption rather than that in upstream or downstream life-cycle stages. The indicators are relevant to waste minimization (and therefore to cost savings) as well as to resource conservation objectives. The complementary indicator was designed to reflect an expanded focus on waste minimization.

Figure 3.1

Minimum Indicator Set

$$\frac{\text{Total mass (weight) of material used directly in the product and co-product}}{\text{Total output of product and co-product}}$$

$$\frac{\text{Total mass (weight) of material used directly in product and co-product + total indirect material}}{\text{Total output of product and co-product}}$$

Figure 3.2

Complementary Indicator

$$\frac{\text{Total mass (weight) of materials and packaging recovered, recycled and reused}}{\text{Total output of product and co-product}}$$

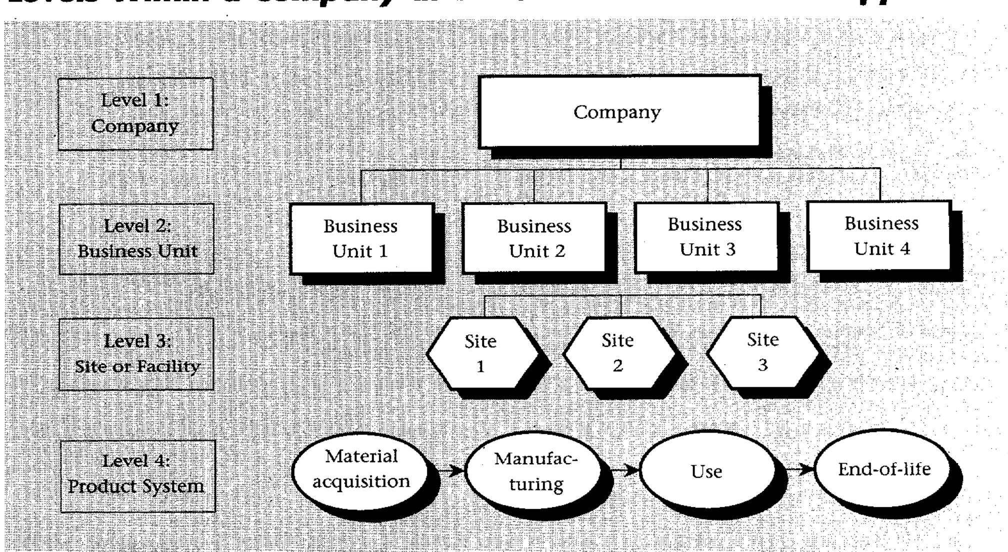
In these formulas, inputs include materials directly incorporated in the product and co-product, and indirect (ancillary) materials used in the manufacturing process to produce the product and co-products. Materials include raw materials, packaging and water (excluding non-contact water).[8] Indirect material is material used in production but not included in the final product. Packaging material included with the product and co-product is regarded as a material for these indicators.

For the denominator chosen, the materials consumed per unit of output for a product or service could be expressed in physical (e.g., per kilogram), operational (e.g., per number of uses) or financial (e.g., per dollar value added or revenue) terms.

The companies acknowledged that the material intensity indicators can be used at different levels within a company (e.g., company, business unit, site or product, see Figure 3.3). In order to provide a frame of reference, a unit process template was developed, (i.e., raw or intermediate material inputs; ancillary materials; energy and water consumed; environmental releases; and output intermediate materials; or final product and co-products, see Figure 3.4).

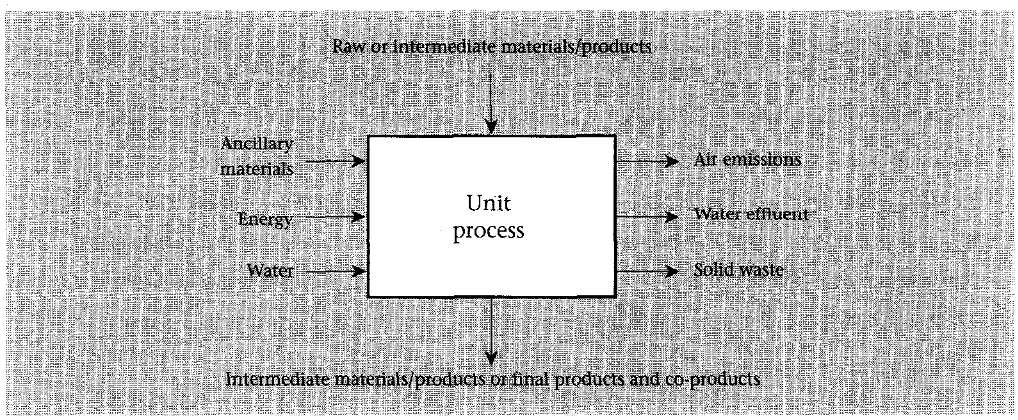
Figure 3.3

Levels Within a Company at Which Indicators Can be Applied



8. This refers to cooling or heating water that is not chemically modified by the manufacturing process (i.e., that does not contact the direct material flows).

Figure 3.4
Template for Unit Process



Lessons Learned

The companies' work on material intensity indicators yielded many insights of which four are particularly important:[9]

1. A material intensity indicator is not particularly relevant or meaningful for extractive industries or for service industries. For example, in the mining industry, the primary material flow is ore (much of which is considered waste) that is extracted and processed into one or more mineral concentrates, which are then refined into metals; in this industry, therefore, the mass of the material input far exceeds the mass of material in product output. The companies also concluded that primary and secondary manufacturing industries are likely to find more use for material intensity indicators than are consumer product assembly, formulation and packaging industries — where the mass of material output in a product may not differ significantly from the mass of material input.
2. Changes in product mix can result in a company's material intensity indicator not reflecting improvements in material intensity at the plant or overall company level.
3. Caution needs to be exercised in industries where the use of large masses or volumes of one particular substance, such as a gas or a solvent, may overwhelm the indicator.

9. These are described further in "Technical Feasibility Issues" below.

4. Related to the previous issue is the effect of water (which may be transformed to another state but rarely destroyed).[10] Where water is included in a product, it should not normally be included in the calculation of the indicator, either as an input or an output. Where water is used for non-contact cooling or heating purposes, it should be omitted as a material (although its condition or quality after use may need to be addressed, perhaps under pollutant dispersion indicators). A separate water consumption indicator may be needed, however, when water is included in products or used in production, if that water is taken from and not returned to a location where water scarcity is a concern (e.g., a particular aquifer, an arid country).

3.2 Decision Rules and Definitions

Decision/Accounting Rules for the Indicators

Study participants agreed on decision/accounting rules for use with the energy intensity indicators relating to the materials that would be included in the calculations.[11] The primary rule was that all materials relevant to the product and/or process would be included. Two rules for determining relevance were:

- all materials that make up more than 1 per cent by mass of the products and co-products leaving the manufacturing site would be identified. From these, materials having a cumulative mass contribution of at least 90 per cent of the total weight of products or co-products would be included; and
- the 17 most significant materials, ranked by mass, would be included.[12]

Definitions

Participants in the feasibility study agreed upon the following definitions for the material intensity indicators:

Indirect/ancillary material: Input that is used by the unit process producing the product or service but is not incorporated in any of the product outputs of the unit process.

Co-product: Any two or more products coming from the same unit process.

Waste: Any output that is disposed of to the environment.

Life-cycle: Consecutive and inter-linked stages of a product system, from raw material acquisition or generation of natural resources to final disposal.

Final product: Product that requires no additional transformation prior to use.

Intermediate product: Input or output from a unit process that requires further transformation.

Raw material: Primary or secondary material that is used to produce a product or service.

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10. See further under "Material Intensity and Water Use" below.
11. Additional background information and technical detail are provided in the workshop reports available from the NRTEE.
12. This number was selected as being sufficient in most cases.

Data Collection and Quality Rules

As with the energy intensity indicators, each company was to be responsible for its own data collection and handling. It would describe and document its data collection and calculation procedures, as well as its verification techniques.

Materials would be measured in kilograms. If an indicator were normalized to a product or service, allocation based on mass would be used where multiple products were produced from the same facilities (e.g., to reflect different grades of paper from a mill). The relevant time period for data measurement would be decided on a company-by-company basis. For the complementary indicators, companies were required to document their calculations, assumptions and decision rules for including and/or excluding materials.

Companies would report on the source, nature and quality of their data, and provide estimates of variability in the same way as they did as for the energy indicators. They also would indicate whether their data were primary, secondary or surrogate and whether they were measured, calculated or estimated. Both qualitative and quantitative data quality indicators could be used. Participants were encouraged to document their costs and the business benefits of conducting the pilot test.

3.3 Technical Feasibility Issues

In developing and implementing material intensity indicators, the companies encountered similar types of issues to those faced during their energy intensity work.

Availability of data: In many cases, the availability of data for measuring the indicators was not sufficient, particularly for material inputs (although waste output often could be tracked). This was the case for Nortel Networks and Bell Canada, which both experienced difficulties in calculating their material inputs. For Bell Canada, although the company could control its waste and recycling activities, it could not control and measure what came into its offices. Furthermore, the quality of data varied, especially the quality of external data (such as data coming from suppliers). For example, Nortel Networks has several thousand suppliers, both internal and external, and sufficiently detailed information about incoming materials is often not known. Procter & Gamble encountered similar data availability and accuracy difficulties, particularly when using external data.

Allocation procedures: The companies encountered problems with their allocation procedures (e.g., when allocating material inputs to the different metal concentrates that could be extracted from an ore). In some cases, allocation should be made on a mass basis, and in other cases it should be on an economic basis. Another challenge arose when companies were dealing with the allocation of indirect materials, maintenance supplies and energy among many products. Procter & Gamble experienced this for data that were not collected at a sufficiently low level of specificity. Nortel Networks, which produces hundreds of manufactured products by multiple operations, had difficulty allocating and crediting materials to specific final products.

Changing product mix: Changes in product mix can affect the calculation of indicators and produce results that do not reflect performance accurately. Furthermore, such changes (e.g., in new and discontinued product lines) present challenges for developing consistent and reproducible indicators over time. Both Procter & Gamble and 3M discovered that changes in product mix could produce results that did not properly reflect improvements in environmental performance.

Several technical issues unique to material intensity indicators were also identified.

Extractive industries: For the reasons given ("Lessons Learned," item one) the two resource companies participating in the study, Alcan and Noranda, found the material indicators had only limited applicability to their operations as a meaningful measure of eco-efficiency. Accordingly, they did not attempt to measure material intensity. For such companies, where the dominant material flow is from ore extraction to refining, the material intensity depends primarily upon the grade of ore rather than upon the efficiency of the extraction process used. Because ore quality has such a major effect on material intensity, meaningful comparison of results between companies is difficult on the basis of material intensity alone. This may be an issue encountered by other extractive companies and resource producers.

Service companies: As the two service companies participating in the study, Pacific Northern Gas and Bell Canada encountered special challenges in developing the indicator. Neither company manufactures a product, although in their operations they both use materials that have environmental impacts. For example, as noted under "Availability of data" above, Bell Canada's attempt to measure material use in its main offices was problematic.

Life-cycle considerations: The product life-cycle should be considered, since the use phase for some products can be more material-intensive than the manufacturing phase. For example, life-cycle considerations are important for consumer goods packagers such as Procter & Gamble, because most of the material consumption for such goods occurs upstream (raw materials production) and/or downstream (product use) in the life-cycle. Overall material intensity therefore should include the upstream supply of materials, consumer purchase and use habits, and disposal. A life-cycle perspective is also important internally for product design, and is important externally to help stakeholders understand the overall environmental effects of products.

Material Intensity and Water Use

Water use posed a particular technical challenge for some participants.[13] Including water use in the indirect indicator calculation could be problematic, since it strongly influenced the outcome for certain products and masked more meaningful information

13. Solvent use could create a similar problem in some circumstances.

about other raw materials. For example, Procter & Gamble found that including water for tissues and towel products overwhelmed the indicator calculation. Separate water indicators should be considered, one dealing with consumption or movement of water where water scarcity is an issue (i.e., at the geological source or geographic location of the water), and another that addresses water condition in terms of quality of discharge.

Table 3.1 summarizes the material intensity indicator selection and key results of the feasibility study for the eight participating companies.

Table 3.1

Material Intensity Indicator Selection and Results Summary

Company	Minimum indicator — denominator chosen	Complementary indicator(s)	Level/scope	Time frame; data quality indicators
3M	Direct; kg/kg	Not initially	Manufacturing site	One year; not chosen
Alcan	N/A	N/A	N/A	N/A
Bell	Modified measure of waste/employee	No	Building	One year; not chosen
Monsanto	Direct; value added	Yes	Company for minimum set, product line for complementary	One year; expert review
Noranda	N/A	N/A	N/A	N/A
Nortel Networks	Direct; cost of sales	Yes	Company	One year; not chosen
Procter & Gamble	Attempted direct & indirect, but effort terminated due to size of effort & data quality issues	For packaging only	Various levels — company, business unit & product line	Varies; completeness & representativeness
WestCoast Energy/ Pacific Northern Gas	Data not available	Data not available	Data not available	Data not available

3.4 Use and Interpretation Issues

In developing and implementing the material indicators, the study participants explored ways to demonstrate that the indicators add value to decision making, and ways to prevent the indicators from misinforming audiences and decision makers. As discussed below, the key challenge is to assemble complex data sets and convert them to simple indicators that are technically sound and environmentally meaningful for internal and external audiences. Given the diverse nature of materials and the industry sectors that use them, material intensity indicators will likely require careful interpretation and use in decision making. Similarly, communication of such indicators will benefit from explanatory notes as to their context and relevance. Through the testing conducted in this project, and where applicable and used in context, the material intensity indicators proved useful both as a management and as a corporate reporting tool.

The same or similar issues relating to use and interpretation of the indicators arose for both the energy and material intensity indicators. These are summarized below.

Aggregation: Data aggregation presents a challenge to the development of consistent and reproducible indicators. High degrees of aggregation across different product lines, facilities and manufacturing sites can mask relevant performance data. When measuring material intensity, aggregating data into an overall indicator has the potential to oversimplify results and lessen its usefulness for tracking eco-efficiency and guiding decision making. Communicating meaningful information to internal and external audiences can also be difficult with highly aggregated indicators, as can achieving credibility for the results. Communicating the appropriate use of the indicators was seen to be a key factor in this regard (e.g., for reporting a company's eco-efficiency progress). The use of aggregated indicators can also make it difficult to make meaningful comparisons between companies and products, etc.[14]

Number of indicators: Study participants expressed concern that a small number of highly aggregated indicators may not be as meaningful internally, nor as useful in determining possible improvement opportunities, as a suite of indicators. A suite may be required as well to reduce perverse results and redundant reporting (double counting). Most participants agreed that a wider set of indicators should be explored in order to satisfy the diverse needs of broader audiences. These needs might arise where water scarcity and quality vary according to geological source or geographic region, requiring the use of water indicators; in solvent recovery and

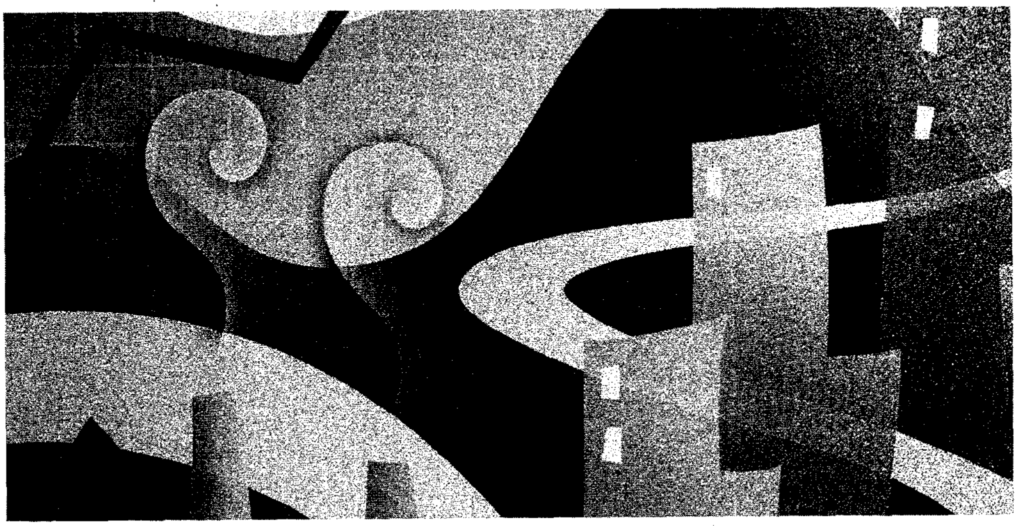
14. Related to aggregation issues is the role of product mix in the indicator calculation, in that changes in the product mix (that can occur frequently and rapidly) can affect the metrics of aggregated indicators even though they are not related to performance (see further above under "Technical Feasibility Issues"). Such changes in product mix will alter trends over time as will design and other improvements. In addition, the specific product mix among consumer goods manufacturers varies widely; where this occurs, meaningful comparison can be facilitated by explanatory notes.

recycling systems where losses and not total use per unit may be more relevant; where non-product material streams are recycled and reused rather than consumed; and where renewable and recycled materials are used.

Numerator selection: In numerator selection, a trade-off exists between the desire of some audiences for comparability and the unique issues faced by different industrial sectors. The numerator for the complementary indicators might vary by sector (e.g., in choosing a boundary for the indicator that reflects a different range of a product's life-cycle).

Denominator selection: Of the two denominators considered — unit of revenue or unit of production — the financial denominator was preferred, especially when the indicator was used for a higher organizational level. However, such a denominator might not be as meaningful for product manufacturers and commodity producers. Although both denominators might be difficult to standardize because of the different approaches that can be used to select the measures, a standard denominator for industrial sectors was seen as necessary by some.

Proprietary issues: As for the energy intensity indicator, some companies expressed concern that the use of financial denominators in the indicators might disclose proprietary, confidential and/or competitive information.



4. Pollutant Dispersion Indicators

4.1 Overall Conclusion

In evaluating options for pollutant dispersion indicators, the study participants concluded that such indicators must address a range of public concerns about releases to the environment that cannot be reduced to a single indicator that would have any useful meaning. The purpose of these indicators must be to help users — internally and externally — to focus on reducing a range of harmful releases to the environment, to support priority setting based on risk, and to communicate about progress toward targets. Releases of concern include more than just those substances that happen to be included in national and international lists of substances designated as "toxics" at a particular point in time.

The most workable approach is considered to be the selection and design of a suite of indicators relating to the issues or categories of greatest common concern. These categories might, for example, be smog precursors, atmospheric ozone depletors, GHG emissions, or dispersion of "priority toxics" in water. Where the science is sufficiently advanced, aggregation of substances within specific issues (such as GHG or ozone-depletion issues) may be appropriate. Design and implementation of an adequate set of pollutant dispersion indicators is going to be an evolutionary process, and it is likely to take longer than the development of the energy and material intensity indicators. Flexibility will be needed to allow for the fact that, over time, some environmental releases will become less important — such as when emissions of ozone-depleting substances are addressed and brought under control internationally — and new issues may be identified.

The eight companies made valuable progress toward the selection of a suite of issues-related pollutant dispersion indicators that would, after design and testing, be meaningful, widely applicable and scientifically acceptable. A useful next step would therefore be for a cross-section of companies to design and test indicators for a few selected issues, such as GHG emissions (for which data are generally readily available), smog precursors and atmospheric ozone depletion. Scientific research is needed to determine ways to aggregate various substances and releases within categories in ways that are acceptable and meaningful.

4.2 From Toxic Dispersion to Pollutant Dispersion Indicators

The toxic release indicator as originally proposed by the NRTEE was based on a numerator that aggregated masses of toxic substances released during an operating period or during product manufacture. The aggregation process involved adjusting each toxic substance by a toxicity weighting factor. This indicator was intended to address the third element of eco-efficiency — reducing toxic dispersion — in a literal sense.

Stakeholders at the Washington workshop had strongly supported in principle the need for a toxic release indicator, recognizing that some countries already collect and report toxic release data for regulatory purposes. Examples include the United States with its Toxic Release Inventory (TRI) program and Canada with its National Pollutant Release Inventory (NPRI) program. However, the lack of international consensus on priority and other substances to be addressed, and the lack of scientific evidence as to their relative toxicity, were viewed from the outset as serious impediments to a single indicator approach.

In the early stages of planning the feasibility study, proposals focused on the design and testing of two toxic dispersion indicators based on aggregation of substances from existing toxic registry lists. During their discussions, however, the study participants realized that addressing the dispersion of toxics is problematic in two ways. First, it is difficult in terms of substance selection and aggregation; and second it is too narrow an approach when public concerns extend to a broader range of non-product outputs regarded as pollutants.

Further, firm consensus emerged that no single indicator based either on toxic substances alone or on a broader list of pollutants was likely to communicate effectively to users about toxic or other non-product output releases to the environment. The study participants therefore concluded that design of a core set of toxic or pollutant dispersion indicators would only be workable and acceptable when there was sufficient international consensus on 1) substances that cause concern and on 2) weightings that reflect relative hazard and toxicity that might permit meaningful aggregation into a small number of indicators. (For a summary of the discussions leading to these conclusions and the issues raised concerning the original proposals for toxic dispersion indicators, see Appendix B.)

Attention next turned to an approach based on a small set of indicators for the categories of pollutant dispersion that are of broad public and international concern. Study participants began to seek consensus on categories for pollutant dispersion indicators that might eventually be widely acceptable and feasible to measure and report in a meaningful way. Such categories or classifications would use terms or words that are generally understood and that reflect broad, general areas of public concern.

The possible categories for indicator development that emerged from discussions were grouped under broad, general areas in a preliminary model. Two of the major general categories in this model reflect environmental media, and one reflects issues causing concern on a global scale such as climate change. Within each general category, appropriate issues phrased in terms used by the public would be identified. Possible examples of general and specific categories within this model are shown in Table 4.1.

Table 4.1

Possible Indicator Categories

General category	Specific pollutant categories to consider
Water	• dispersion of "priority" chemicals • other dispersed pollutants
Air	• acid rain precursors • smog precursors • dispersion of "priority" chemicals • other dispersed pollutants
Global issues	• greenhouse gas emissions

The "priority" substances in Table 4.1 refer to bio-accumulative, persistent toxic compounds according to, for example, Canada's voluntary ARET (Accelerated Reduction/Elimination of Toxics) scheme.[15] ARET lists chemicals under the following five-part classification system:

A1 Highly toxic, bio-accumulative and persistent (consensus on chemicals relative to criteria)

A2 Highly toxic, bio-accumulative and persistent (consensus not reached)

B1 Highly toxic and bio-accumulative

B2 Highly toxic and persistent

B3 Highly toxic

A number of other categories were also identified by the study participants for consideration:

For releases to water:

- oxygen depletors
- microorganisms
- eutrophication

For releases to air:

- particulates
- stratospheric ozone depletors

For releases to land as well as water and/or air:

- endocrine disruptors
- managed waste — hazardous and non-hazardous

15. For further details about the ARET system, see ARET Secretariat, National Office of Pollution Prevention, Environment Canada, *The ARET Substance Selection Process and Guidelines* (January 1994).

To report such releases as absolute masses in a valid and meaningful way may in itself be scientifically challenging; to do so in the form of an indicator that relates these masses meaningfully to unit of product or value created is even more challenging. Progress will be gradual, depending on continuing advances in scientific understanding of the effects of releases on human and other life forms, which in turn will affect levels of perceived and actual risk.

4.3 Further Technical Issues for Pollutant Dispersion Indicators

Further technical issues that arose are summarized below.

Overlap with energy indicators: The potential overlap with energy indicators (C6) for energy-related GHGs was noted in Chapter 2. As a result, there is a need to decide whether GHG-related indicators should be a completely separate category or should be considered within the energy intensity or pollutant dispersion suites of indicators.

Aggregation: For pollutant dispersion indicators, aggregation of data about different substances is a fundamental problem. Aggregation could oversimplify complex environmental issues or concerns. The majority of study participants felt that there should be disaggregation of pollutant dispersion indicators, with some calling for more information or indicators under each broad category (e.g., dispersion of priority toxics to water). An alternative view was that some aggregation is preferable to avoid having too many pollutant dispersion indicators, which could overwhelm the other indicators.

Methodology: As with the material and energy indicators, consistency with respect to the methodology for data collection and handling is required for pollutant dispersion indicators.

Name for indicators: The appropriateness of the name "pollutant dispersion indicator" may need further consideration. "Pollution indicator" and "pollution intensity indicator" were suggested as possible alternative names. These names, along with the current "pollutant dispersion indicator," need to be informally tested with various internal and external audiences.

Denominator: Study participants agreed that the same denominators used for the energy and material intensity indicators (unit of production or unit of revenue) should be used for pollutant dispersion indicators. In discussing the denominator, the participants' primary concern was confidentiality, particularly within the chemical industry. In the feasibility study, companies were not being asked to disclose confidential information and could take whatever steps necessary to ensure confidentiality (e.g., rolling up data or using a value-added type of denominator).

Other technical observations regarding pollutant dispersion indicator development were as follows.

Regulations: Regulations are a moving target. In many jurisdictions, new programs are evolving, and there is a trend toward developing a common international list based on current national pollutant lists. Generally, pollutant dispersion indicators must be able to distinguish those substances with a demonstrated higher level of activity (e.g., highly toxic, persistent and bio-accumulative substances) from the broader population of chemicals.

There is wide variation not only between different regulatory jurisdictions, but also within jurisdictions, with regard to the regulated "level" of pollutants. This may vary between provinces and states, as well as between countries. There are also wide variations between the pollution release and transfer registries of different jurisdictions — for example, the ARET, TRI and NPRI lists — which make it difficult to arrive at a common list of reportable pollutants. Analytical differences also exist between jurisdictions. For example, biochemical oxygen demand (BOD) is measured on a five-day basis in Canada and the United States, whereas an eight-day basis is used in Nordic countries. Sulphur dioxide and nitrogen oxides are also measured differently in different countries.

Level of indicator: Indicators, by definition, are not meant to deal well with in-depth issues. However, broad indicators can be developed for the board of directors that will also be of interest to the public. The study participants believed that indicators at this level would need to be highly aggregated so as not to overwhelm users with detailed information, although they could still provide directional information on the sound management of pollutants.

Indicator categories: Emission or impact categories for which indicators are developed must be dynamic, that is, they must be capable of changing over time. This is because some issues will be addressed over time and become less important (e.g., many companies have already addressed ozone-depleting substances), while new issues will emerge (e.g., endocrine disruptors).

Risk-based approach: Looking at inputs and outputs in terms of risk requires more detailed accounting of releases and where they end up through transportation and food chains, since risk is tied to exposure as well as inherent biochemical properties. For example, solubility and transformation to bioavailable forms are key risk considerations with respect to the release of inorganic compounds. Therefore when, where and at what rate a pollutant is released is of significance.

4.4 User Issues

The context for pollutant dispersion indicators is shaped by user expectations that do not yet clearly point to any particular indicator, but which need to be taken into consideration. Furthermore, lack of comparability between pollutants makes comparison between companies reporting different pollutant releases difficult.

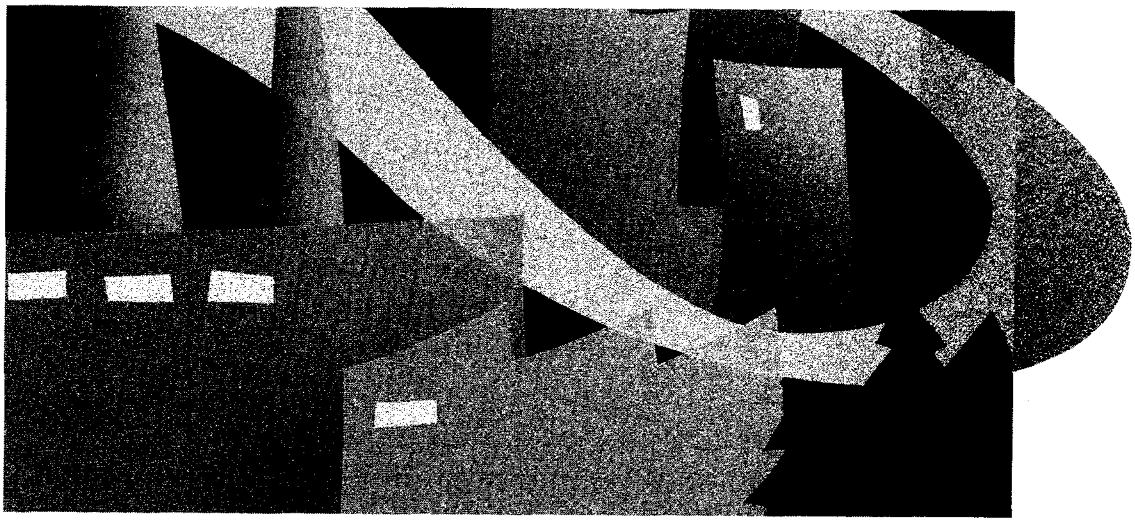
For many companies, the primary motivation for management (and many boards of directors) to track pollutant releases is the need to manage and prevent liabilities, to comply with regulations (including those that require reporting releases of prescribed substances, e.g., under the TRI or NPRI), and to anticipate and possibly influence public policy issues and agendas. Many companies may not yet perceive further value-added benefits from this activity. However, there is a trend for companies to report pollutant releases in a comparable manner so as to demonstrate progress in improving environmental performance and fulfilling public commitments.

Governments and regulatory agencies are likely to continue implementing requirements for companies to report releases of toxic substances and other pollutant releases, such as smog precursors, acid rain precursors, ozone-depleting substances and GHGs. The trend will likely intensify as countries begin to address their obligations or targets under international treaties. In this respect, the Kyoto climate change commitments may be of special significance, particularly as emissions reduction trading schemes are introduced.

These types of commitments and related reporting requirements may result in costs for companies and create sources of business uncertainty and risk; they also make certain types of performance data publicly accessible. Capital market participants, especially lenders, institutional investors and financial analysts, are likely to become more interested in reliable information about aspects of performance such as pollutant and toxic emissions that represent business risk and may affect long-term shareholder value creation.

Community, employee and other stakeholders in general are also likely to continue to seek reliable, meaningful information about such matters.

For many users, a well-designed eco-efficiency approach to reporting on toxic or pollutant releases appears to be superior to reporting only releases of prescribed lists of substances. Perhaps more importantly, pollutant dispersion indicators are an almost essential complement to materials and energy indicators, because the combination can provide users with signals about whether improvements in material or energy intensity are being accompanied by increased or decreased levels of pollutant or toxic dispersion.



5. Conclusions, Lessons and Future Directions

5.1 Conclusions

The study resulted in the following overall conclusions.

1. Core indicators for energy intensity — energy consumed per unit of output — are widely applicable and meaningful, and may be readily implemented by many companies. Energy-related GHG emissions call for special attention and may be addressed better in designing pollutant dispersion indicators. Practical issues concerning implementation and interpretation have been identified, decision rules have been established, and the stage has been set for broader testing and demonstration of this indicator.
2. Core indicators for material intensity — materials consumed per unit of output — are feasible, but are more applicable and meaningful in some industry sectors than others. Any company implementing these indicators needs to take into consideration the special factors that are associated with the nature of its business and its products, in particular the effect of water used in production processes and water included in product output. Further studies on these indicators by a wider range of manufacturing sector companies will be valuable.
3. The design of a small set of meaningful eco-efficiency indicators for pollutant dispersion requires more consideration and research. However, a suite of indicators related to key issues of public concern is more likely to be feasible and useful than any single aggregate indicator. Pollutant rather than toxic dispersion was considered to be a more appropriate term for the range of releases that are of public concern.

The active participation of the eight companies in evaluating possibilities and their experiences in testing the indicators yielded important insights and lessons about what works, what is relevant and meaningful, and what is required for implementation of the proposed indicators.

5.2 Lessons Learned

The lessons learned and challenges identified in designing, implementing and interpreting the three types of indicators are summarized below.

Technical Feasibility

The key issues identified relating to technical feasibility were:

- agreeing on acceptable levels of precision in measurement, thresholds and scientific validity;
- choosing between indices (relative to a base level or year) and normalized indicators (relative to unit output or value added);
- establishing numerators and denominators that will produce meaningful information, and deciding whether users find more meaning in indicators that show improvement by upward or downward directional trends (some users may be accustomed to expect one direction, others the opposite direction);

- setting levels of aggregation that are meaningful without masking important information;
- avoiding arbitrary allocations of performance data between products or facilities;
- accommodating fluctuations in product lines, acquisitions and disposals of businesses and divisions, major shifts in production volumes; and
- addressing the availability, completeness and quality of internal and external data for indicator calculation.

Use and Interpretation

Other challenges relate to the meaning that users may ascribe to indicators and the completeness of information provided about environmental performance. The participating companies identified a number of challenges concerning the use and meaning of indicators.

- An indicator that may be effective in prompting a CEO or board of directors to ask appropriate questions and initiate further inquiry may be less meaningful or useful to management of a facility or product line.
- Indicator design has to guard against the "perverse effect" problem, that is, the risk that a particular indicator by itself may trigger a decision by a user to improve one aspect of performance, while unintentionally causing an adverse effect in some other aspect of performance. A set or suite of indicators and other information may be necessary to provide appropriate directional context for proper understanding of any one indicator.
- One unresolved aspect of indicator design is whether the numerator should relate to environmental burden (e.g., materials and energy consumed, pollutants dispersed) and the denominator to output or value created, or vice versa. Users in different parts of the world have different expectations and perceptions as to the directional trends of indicators that are most readily understood or considered desirable.
- A core set of eco-efficiency indicators is not expected to communicate all the necessary information about a company's environmental performance. The companies participating in the feasibility study confirmed that other quantitative (e.g., absolute) measurements and qualitative information are often also necessary to provide a complete and meaningful picture of environmental performance. Explanatory notes about specific indicators may also be helpful to users in properly interpreting the meaning of indicators — these would be analogous to notes to financial statements.

Indicator Development

The NRTEE effort has demonstrated a prototype process for the development of eco-efficiency indicators. The key to progress for such indicators is active, phased experimentation and shared learning among companies to discover which eco-efficiency indicators are the most appropriate, meaningful and cost-effective to produce. The phases in this process may be summarized as follows:

- consideration of indicator needs by a wide audience of stakeholders;
- agreement by volunteer companies on a technical framework and operating rules to test defined indicators;
- actual feasibility testing and sharing of learning by participants; and
- further testing and drawing of conclusions.

The next stage in this process would be refinement and wider demonstration projects with a larger and more diverse group of industry volunteers.

Appendix C shows this process within the context of the NRTEE feasibility study.

5.3 Future Directions

As a result of the feasibility study, the NRTEE recognizes that active experimentation by companies is vital to progress in developing indicators. Learning and consensus building based on the results of such work is invaluable to complement insights from other stakeholder consultations and research initiatives. Specific next steps to consider, as identified by study participants, are set out below.

Next Steps

Energy intensity indicators
Further work to develop energy intensity indicators should include building external credibility, standardization of numerators and denominators, and determining how many and which of the complementary indicators to pursue. Linking energy intensity indicator development with climate change initiatives targeting GHGs is also considered important.

Material intensity indicators
The next step in developing material intensity indicators is to test the use of these indicators in a wider range of companies, particularly those in the manufacturing sector, which was under-represented in the feasibility study. Further refinement of definitions and decision rules for inclusion is also needed (i.e., for direct and indirect materials). Consideration should be given to the design and testing of a wider set of indicators, such as a separate water indicator, and to indicators that address waste management and reuse and recycling of materials.

Pollutant dispersion indicators
Continued design, testing and evaluation of pollutant dispersion indicators by companies and industry associations are needed. As previously suggested, a concrete and useful next step would be for a cross-section of companies to design and test indicators for three issues, such as GHG emissions (for which data are generally readily available), smog precursors and atmospheric ozone depletion. Further scientific research is needed to support aggregation of data into meaningful pollutant dispersion indicators. Industry associations might play a useful supporting and/or coordinating role in this effort.

Common Themes

Continuing experimentation by companies

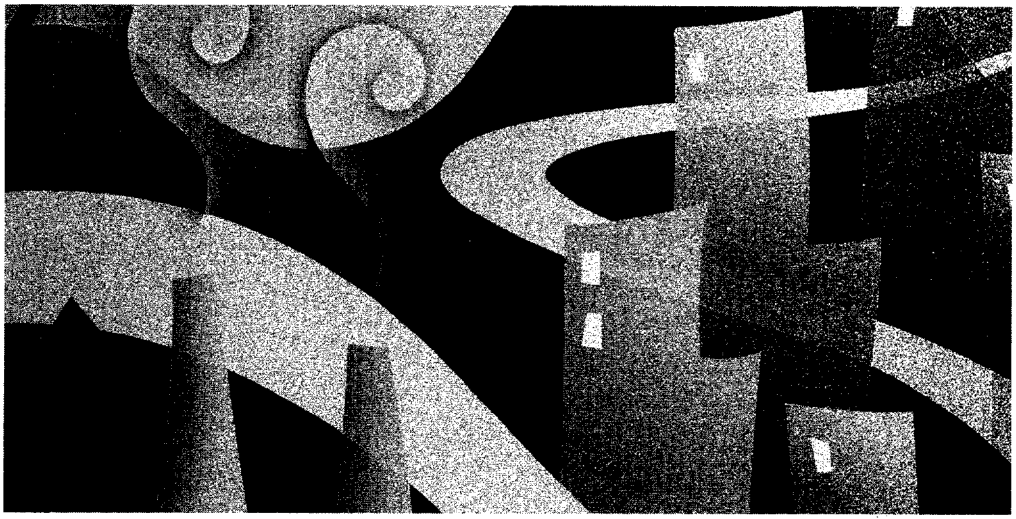
Continued evaluation by the participating companies and testing by a wider group of companies will be important, to build on the lessons learned from this project. The NRTEE will seek cost-effective ways to facilitate sharing of experiences among participating companies and is planning a progress review meeting later in 1999. Recruiting more companies from a wider cross-section of sectors to test the energy and material intensity indicators and to further the design and testing of pollutant dispersion indicators is also very desirable.

Roles for industry associations

Industry associations may be able to play a useful role in encouraging companies to experiment with the design and implementation of eco-efficiency indicators, by carrying out related research (into pollutant dispersion indicators, for example) and by developing and disseminating sector-specific guidance about eco-efficiency indicators.

Wider communication and use of the study

Communication of the results of the study will be valuable to industry and business associations and to other stakeholders. Learning how to interpret the indicators may be as important as developing and reporting them. Integration of the feasibility study results with eco-efficiency measurement and reporting initiatives by other organizations in Canada and internationally will also be valuable.



Appendices

Appendix A

The Participating Companies

Name of company	Company products or services	Company statistics	Level at which study conducted	Responsibility for study	Environmental performance reporting	Lessons learned/ utility to company	Future plans & recommendations
3M Canada	Tape, abrasives, adhesives, encapsulated products, cleaning filtration products, anticorrosion pipe coatings, health care products	Worldwide: 70,000 employees in 200 countries, over 50,000 products, annual global revenue US$14 billion Canada: 7 plants, 1,000 employees	Two manufacturing facilities in Canada	John Howse, Manager — Environment, Heath & Safety; Ian Service, Senior Specialist, Environment & Regulatory Affairs Contact at: jrhowse@mmm.com	Reports issued periodically (2 in last 3 years)	Material indicators less useful than waste indicators already in use; energy intensity indicators already in place; interested in GHG indicators.	Will continue until feasibility testing period complete.
Alcan Aluminium	Aluminum industry: bauxite mining, alumina refining, power generation, aluminum smelting, manufacturing & recycling. Produces and markets aluminum products. Is the world's leading supplier of flat-rolled aluminum.	Parent of worldwide group of companies involved in all aspects of aluminum industry; operations in 30 countries; over 33,000 employees worldwide	Site, significant unit processes	Steven Pomper, Director of Environment Contact: steven.pomper@alcan.com	Corporate report every 3 to 5 years; annual report at site level; some regional reporting planned.	Material indicators not applicable. Interested primarily in energy and GHG indicators. Communication is key to establishing consistency & rigorous uptake.	Will incorporate energy and GHG indicators in annual assessment process. More work required to harmonize PDIs across companies

The Participating Companies (continued)

Name of company	Company products or services	Company statistics	Level at which study conducted	Responsibility for study	Environmental performance reporting	Lessons learned/ utility to company	Future plans & recommendations
Bell Canada	Canada's largest telecommunications provider.	7 million customers in Ontario & Quebec; approx. 42,000 employees; gross annual revenue over C$8.5 billion	Office building	Yves Ouimet, Director of Environment Contact at: youimet@qc.bell.ca	Annual environmental performance report	Indicators pose unique challenges to service companies. Data collection difficulties.	Will continue developing and testing indicators with a view to ongoing use.
Monsanto	Biotechnology, food ingredients, pharmaceuticals, agricultural products.	23,000 employees in 150 countries; over 500 products; annual global revenue US$8 billion	Company and one product line	Earl Beaver, then Director of Waste Elimination Contact: CHARLES.W.KEFFER.JR@monsanto.com	Reports issued annually	Prefers value-added denominators; packaging information difficult to obtain; energy co-generation contentious; significant concern re data adequacy, reliability & comparability; perverse results.	Needs to work more closely with Centre for Waste Reduction Technology (U.S.); needs more contact with Europe and NGOs.

The Participating Companies (continued)

Name of company	Company products or services	Company statistics	Level at which study conducted	Responsibility for study	Environmental performance reporting	Lessons learned/ utility to company	Future plans & recommen-dations
Noranda	Mining & metallurgical: leading producer of zinc & nickel; also produces copper, primary & fabricated aluminum, lead, silver, gold, sulphuric acid, cobalt & wire rope; major recycler of secondary copper, nickel & precious metals.	Total mining & metal assets of C$8.9 billion at year-end 1997; 80% of products sold outside Canada; over 21,000 employees worldwide	Site	Leonard Surges, Manager, Environment Contact at: SurgesL@Noranda.com	Annual environment, safety and health report	Material indicators not applicable; high level of interest in energy and GHG indicators. Issues: data availability, allocation, denominator selection.	Consider internal use and external reporting of appropriate energy intensity indicators.
Nortel Networks	One of the world's largest suppliers of digital network solutions, e.g., communications and Internet protocol optimized networks.	Conducts business in over 150 countries; approx. 80,000 employees; 1997 revenue of US$18 billion	Company	Tony Basson, EMS & Environment Performance Specialist Contact at: tbasson@nortel.com	Annual reports	Issues: data collection, indicator scope & definition, denominator selection.	Will continue to develop and use indicators.

The Participating Companies (continued)

Name of company	Company products or services	Company statistics	Level at which study conducted	Responsibility for study	Environmental performance reporting	Lessons learned/ utility to company	Future plans & recommendations
Procter & Gamble	Consumer goods, incl. laundry & cleaning products, kitchen towels, bathroom tissue, baby diapers, etc.	Approx. 110,000 employees in over 140 countries; 350 product brands; US$35.7 billion in revenues.	Several levels, incl. company, business unit (paper) & product line (paper towels)	Willie Owens, Principal Scientist, Corporate P&RS, Global LCA Technical Development; Amardeep Khosla, Manager, Technical Policy — Canada, Worldwide Technical Policy Contact at: owensjw@pg.com; khosla.as@pg.com	Reports issued annually.	Significant learning benefits for P&G from feasibility study; building on related previous work.	Will continue work where needs are identified for improvements in existing data & indicator reporting practices.
Pacific Northern Gas, owned by WestCoast Energy	Integrated transmission & distribution co.; part of a North American energy company whose interests include a natural gas system, distribution & storage facilities, retail energy products & services.	PNG serves customers in west-central and northeastern B.C.; WestCoast Energy is based in Vancouver, with assets of $10 billion	Data not available.	K.C. Caswell, Team Leader, Engineering & Environment Contact at: cawced@ibmmail.ca	Data not available.	Service company challenges; CO_2 issue (swamping indicators).	Data not available.

Notes: CO_2 = carbon dioxide; NGO = non-governmental organization; PDI = pollutant dispersion indicator

Appendix B

Original Proposals and Considerations for Toxic Release Indicators

This appendix describes the original proposals for toxic release indicators and the issues considered in developing and evaluating those proposals. Although these indicators were not tested in a feasibility study, many important issues, concepts, definitions, decision rules and practical lessons came to light in the process of considering them.

The toxic release indicator proposed by the NRTEE was based on a numerator that aggregated masses of toxic substances released during an operating period or during product manufacture. The aggregation process involved adjusting each toxic substance by a toxicity weighting factor. As described in Chapter 4, stakeholder input from the Washington workshop supported the need for a toxic release indicator, and recognized that toxic release data are already being collected and reported in various countries for regulatory purposes. However, such a single indicator approach raised the issue of lack of international consensus 1) on the substances to be addressed and their priority and 2) on scientific evidence about their relative toxicity.

The Washington workshop concluded that:

> *Development of one or more indicators for toxic dispersion or releases is also highly desirable and relatively feasible.... The potential exists to design and implement two toxic release indicators — one related to the goal of virtual elimination of the persistent, bio-accumulative toxic substances covered by international treaties, and one to address a longer list of toxic chemicals, such as those in the U.S. TRI or Canada's NPRI. Further work is needed, however, to examine existing requirements and practices in defining, measuring and reporting toxic releases, and in assessing and comparing their toxicity.*[1]

The NRTEE therefore commissioned a report on current practices regarding toxic release indicators and work on that topic in Canada and elsewhere. The report provided suggestions and a point of departure for the NRTEE Task Force and the eight volunteer companies in addressing indicators for pollutant dispersion.2 Key points from the report, subsequently discussed and challenged in the course of the study, included:

- pollutant dispersion indicators (rather than toxic release indicators) were to be capable of being "used voluntarily by industrial and business organizations to provide a simple, readily understood metric of the organization's performance in eco-efficient management of toxic chemical releases to the environment. The essential elements of such performance indicators are the annual quantity of toxic substances released by an organization per unit of production or business activity."

1. NRTEE, *Backgrounder: Measuring Eco-efficiency in Business* (Ottawa, 1997), p. 36.
2. Peter Robson, *Discussion Paper on International Performance Indicators for Dispersion of Toxic Chemicals into the Environment*, unpublished NRTEE paper, 1997.

- a substance list such as that used in Canada's voluntary ARET program should be considered, since that list groups substances based on concerns about toxicity. The report noted, however, that there is currently no international, generally accepted weighting or ranking of toxicity concerns for reported substances. Moreover, it suggested that, although several countries and industry associations maintain some type of Pollutant Release and Transfer Register, careful attention needs to be paid to the quality and reliability of reported release data.
- the most appropriate type of denominator to 1) deal with year-to-year fluctuations of substance releases and production/activity levels and 2) provide a consistent basis for comparisons would be financial or economic, such as sales or cost of sales.

The report also provided a detailed practical example of the calculation of a possible pollutant dispersion indicator for a hypothetical company.

Early in 1998, the volunteer companies met with the NRTEE and invited experts to develop a plan for testing one or more indicators that would relate to releases of toxic substances. Although the term "pollutant dispersion indicator" was adopted, the study participants' focus continued to be on developing one or two aggregate indicators of toxic substance releases. The outcome of this planning stage was two proposed minimum indicators and related decision rules that the participating companies would each review internally before reconvening to discuss, modify and agree on prior to feasibility testing. Other conclusions reached at this planning stage were as follows.

Purpose and Nature of Work in Developing Indicators

Future work on the indicators should attempt to ensure that:

- the indicators developed help companies engage in an intelligent dialogue both within the company and with outside stakeholders;
- the indicators developed assess the release of pollutants to the environment, not the reduction of chemical use;
- the list of pollutants used in the feasibility study follow the decision rules and is created from existing credible lists of pollutants agreed to by the participating companies; and
- for the feasibility study, the list (of substances) recognize different levels of concerns for pollutants, using criteria such as those in the ARET classification.

Criteria for Developing Indicators

Pollutant dispersion indicators were to be:

- useful as an analytical tool and easy to reproduce from year to year;
- adaptable, that is, capable of being modified over time in response, for example, to scientific evaluations and changes in lists of substances;
- credible to stakeholders and users, and responsive to external concerns;

- applicable in different countries and for sector-specific indicators;
- auditable;
- relevant to both organic and inorganic substances;
- complementary to existing energy and material indicators and other eco-efficiency tools;
- simple to use and easy to understand by audiences representing broad technical and non-technical backgrounds;
- a robust information source for performance improvement, which would not have perverse effects on decision making regarding other aspects of eco-efficiency;
- valuable at several levels within a company, from product to corporate, and for several purposes; and
- capable of being calculated from data and measurements that are available or obtainable in a cost-effective manner and in accordance with clear, appropriate decision rules.

The Proposed Indicators

The following section describes the approach taken and the resulting indicators (based on toxic substance releases) and related decision rules that were originally proposed as the basis for the feasibility study.

What to include in the indicator — Step 1: defining and classifying non-product outputs

Step 1 was to consider the exact scope or categories of what are characterized as non-product outputs (NPOs), since these contain the substances that are to be tracked and incorporated into pollutant dispersion indicators. NPOs are outputs other than the products, services or by-products that are regarded as part of the company's revenue-producing lines of business and are typically the focus of marketing strategies, sales efforts, etc. NPOs therefore include both substances released directly to the environment — to air, water or land, whether deliberately or accidentally — and those that are not released directly to the environment but are managed through recovery (reuse and recycling) or through controlled disposal techniques (e.g., compost, incineration, landfill, transfer to safe storage). There is a possibility of releases to the environment from recovery and controlled disposal processes — whether "within the gates" or after leaving the company's direct control. These were termed "indirect releases."

The full range of NPOs to be considered for pollutant dispersion indicators would be direct releases plus indirect releases. However, the study participants recognized that the latter may present problems where data are not available or the indirect releases occur after managed NPOs have left the company (but are not simply moved between company facilities).

For feasibility study purposes, the volunteer companies agreed to consider at least substances contained in direct releases in their calculations. Indirect releases would be considered where data were available (companies would need to define exactly the nature and source of such indirect releases).

What to include in the indicator — Step 2: deciding what NPO substances to include

Step 2 of the approach proposed for the NRTEE feasibility work was to decide exactly what NPO substances should be included in two proposed minimum indicators, based on measurements of the mass of substances released in NPOs that are included in the TRI, NPRI and ARET lists. These indicators are as follows.

Minimum indicator 1: substances that are common to TRI and NPRI, plus any other additional ones that are common to ARET and TRI. This would result in a list of 195 substances. For the purposes of this indicator, no toxicity weighting was to be applied to individual substances.

Minimum indicator 2: substances common to TRI and ARET, grouped according to classes in the ARET classification system but combining or aggregating these in such a way as to result in three, not five, classes: A1 plus A2, B1 (alone), and B2 plus B3. This would result in a list of 78 substances, grouped in three classes based on the ARET toxicity weighting criteria.

Additional Decision Rules Proposed for Study Purposes

At least for feasibility study purposes, the companies also agreed to track and report total masses under each of the three groupings, so as to allow for experimentation with alternative weighting schemes for indicator design.

Unit of production (or service) was to be the denominator for the indicators tested, but participating companies would have the option to use unit of revenue or value added as the denominator where they considered appropriate.

The companies also agreed to carry out "reality checks" by watching out for instances where there might be significant releases of substances that cause concern but are not included in the above groupings for minimum indicators 1 or 2. A further proposed step was to compare the selected lists with those in European priority substance lists and to consider any discrepancies in due course.

A set of complementary indicators was also considered. These were indicators that the volunteer companies might choose to evaluate as to their conceptual relevance, usefulness and practical feasibility. They might be developed based on modifications to the substance lists proposed above (e.g., GHG emissions, air pollutants [such as smog precursors]), combined NPRI and ARET releases (for Canadian companies), or minimum indicator 1 plus all other TRI substances (for American companies).

For indicator testing purposes, substance releases would be measured in metric units, such as kilograms or tonnes. Data for calendar year 1996 would be used where possible as the time period for which indicators would be calculated. Current NPRI and TRI reporting thresholds would be used for the minimum indicators 1 and 2, recognizing that the differences between these two sets of thresholds would need to be resolved at some stage. In the event of indicators being normalized to a product or service (rather than a financial measure), any allocations of substance releases among products or services would be made on the basis of mass.

Conclusions Regarding the Two Indicators Originally Proposed

Following an extended period of consideration, the companies and Task Force members expressed significant concerns about the two proposed indicators that focused on releases of listed toxics. These concerns included:

- the risk of confusion to users through departure from established (and, to regulators and environmental managers, somewhat familiar) substance lists or inventories such as TRI, NPRI and ARET. Also, companies in the United States would have had to deal with the shift from a strictly mass-based approach to one based on levels of toxicity, persistence and bio-accumulation;
- the challenge of reaching consensus and general acceptance about the design of an appropriate suite of indicators, and the number of indicators needed for meaningful reporting — one or two indicators clearly would not suffice for such a complex topic;
- whether the indicators should encompass or address pollutants such as acid rain or smog precursors or GHG emissions. This issue, while going beyond the original concept of toxic dispersion, was nevertheless seen as a key pollutant release issue;
- the continued need for consensus on the question of denominator(s) for the indicators; and
- the reality that companies were already tracking, reporting and in many cases managing substance releases required under TRI and NPRI, and could not see sufficient value (for internal users, at least) in implementing additional indicator schemes, even ones that use existing data.

Two companies offered further specific comments.

1. Monsanto indicated that its total emissions of toxic substances were small relative to its overall pollutant emissions, and that much of what would otherwise be direct toxic releases to the environment is managed by transfer to various forms of treatment and disposal. These factors suggested it would be appropriate to have a broader range of pollutant dispersion indicators, not just ones relating to the proposed groupings of listed toxic substances. In fact, one indicator for the total mass of all (ARET, TRI, NPRI) substance releases and a second indicator to add in other priority pollutant releases (GHGs and acid rain precursors) had been developed. Both these indicators are normalized relative to a form of value added (sales revenues less cost of raw materials).

2. Procter & Gamble noted that it sees considerable challenges in devising a suite of meaningful, comparable pollutant dispersion indicators for use by external stakeholders. The company prefers an approach that facilitates risk assessment and risk management decisions, focusing on three broad categories of substance releases: TRI substances, high production volume (HPV) substances, and persistent organic pollutants (POPs). For TRI and HPV substances, there is a need to distinguish between actual and managed releases. For POPs, the important issue is management of NPOs rather than direct releases. Further, in a risk-based approach, there are different challenges in assessing toxicity for humans as distinct from toxicity for eco-systems in general.

Attention therefore turned to an approach based on issues or categories of pollutants, as described in Chapter 4.

Appendix C

Chronology of Workshops

The table below summarizes the five workshops held during the course of the NRTEE feasibility study as well as the Washington workshop, and the forum held by the NRTEE immediately prior to Globe '98 in March 1998 to communicate with a wide group of interested stakeholders about the project. Copies of the detailed technical reports prepared following each workshop are available from the NRTEE.

Table C-1

Workshop date, location	Workshop focus
April 2, 1997, Washington, DC	Broad stakeholder consultation meeting
November 12-14, 1997, Toronto, ON	Planning feasibility study for energy and material intensity indicators
January 26-27, 1998, Toronto, ON	Planning feasibility study for pollution dispersion indicators
March 16, 1998, Vancouver, BC	Mid-study progress review — all three types of indicator
March 17, 1998, Vancouver, BC	Forum to communicate with interested stakeholders about study
June 23-25, 1998, Montebello, PQ	Review of findings and conclusions for all three types of indicator
October 15, 1998, Toronto, ON	Review of draft report on feasibility study

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