NATIONAL ROUND TABLE ON THE ENVIRONMENT AND THE ECONOMY
TABLE RONDE NATIONALE SUR L'ENVIRONNEMENT ET L'ÉCONOMIE

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Canada

Measuring Eco-efficiency in Business: Developing a Core Set of Eco-efficiency Indicators

Workshop Report

Prepared for the
National Round Table on the Environment
and the Economy

Based on the Proceedings of
the Eco-efficiency Measurement Workshop

April 2, 1997
Washington, D.C.

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Executive Summary

Workshop background and objectives

On April 2, 1997, in Washington, D.C., the National Round Table on the Environment and the Economy (NRTEE) held a one-day workshop on Eco-efficiency Measurement. The workshop was organized by the NRTEE's Task Force on Eco-efficiency in joint sponsorship with the World Business Council for Sustainable Development (WBCSD). The purpose of the workshop was to explore the possibilities for developing a core set of indicators that business enterprises in all industry sectors might use to measure and report on eco-efficiency. The WBCSD definition of eco-efficiency and its list of seven elements of eco-efficiency were adopted for the purposes of the workshop. A pre-workshop background paper commissioned by the NRTEE, "Measuring Eco-efficiency in Business: Developing a Core Set of Eco-efficiency Indicators", was used as a starting point for the workshop discussions. The workshop was designed to maximize interaction among participants through discussion in break-out groups between the opening and closing plenary sessions. Those present indicated a shared desire for the workshop to reach conclusions as to the path forward and next steps in developing eco-efficiency indicators.

Opening remarks

The first introductory speaker, Mr. Al Aspengren of 3M, representing the WBCSD, set the stage for the workshop by providing an overview of developments in the relationship between business and sustainable development over the last decade, and the evolution of the eco-efficiency concept over the last five years. He stressed that eco-efficiency is not a "business as usual" approach, but calls for a fundamental shift of mindset in order to realize the desired "wins" in value creation for the various stakeholders in business enterprises.

Dr. Stuart Smith, for the NRTEE, indicated that the three eco-efficiency indicators proposed by the NRTEE and discussed in the background paper were intended to serve as catalysts for discussion and consideration of feasible possibilities. The initial emphasis of the NRTEE-WBCSD initiative is on meeting the internal information needs of management and boards of directors of enterprises, not on proposing new external disclosure requirements. The key is to develop and gain consensus to implement a few robust, quantifiable and verifiable indicators that all companies can use and that will allow meaningful, reliable comparisons to be made between companies and over time. Trade-offs between simplicity and completeness will be necessary for progress to be made. Eco-efficiency is recognized as being a subset of sustainable development that may be more readily measured than the full spectrum of social and economic issues which sustainable development addresses. Values for eco-efficiency indicators will vary between industry sectors, just as values for financial indicators do.

Broad considerations for developing eco-efficiency indicators

In addition to the considerations set out by Al Aspengren and Stuart Smith in their opening remarks, the workshop participants identified a number of other broad considerations for developing eco-efficiency indicators:

I. The process of developing these indicators should be voluntary and evolutionary, allowing opportunity for experimentation and evaluation by companies in various sectors.

II. The linkages between eco-efficiency and other aspects of sustainable development, including social values, should be recognized.

III. Eco-efficiency indicators are management tools for informed decision-making, not drivers for goals or policies; these drivers need to be understood, however, in designing appropriate indicators.

IV. Different information users have different needs for eco-efficiency information; transparency and clarity of meaning are important design considerations.

V. Needs for absolute as well as relative or normalized information and measures have to be considered, as well as choices between physical, financial or combined measures .

VI. Aggregation or "rolling up" of data into single, composite indicators may be problematic, either because of weightings or because of particular product line characteristics and differences.

VII. Desire to develop indicators for each element of eco-efficiency needs to be balanced with caution against designing indicators for certain elements which appear to be in conflict with or cause confusion in relation to those for other elements.

VIII. Life-cycle concepts and renewable/non-renewable resource distinctions need particular attention.

Discussion, conclusions and recommended next steps

Workshop discussions in breakout groups focused on the three indicators previously proposed by the NRTEE, resulting in conclusions as to their feasibility, proposals to modify them, suggestions for other indicators and recommendations for future developmental action. The conclusions and recommendations of the breakout groups were summarized in the closing plenary session:

IX. The Resource Productivity Index, important in concept, should deal separately with materials intensity or efficiency, and energy intensity or efficiency.

X. The Product and Disposal Cost to Durability Ratio is unworkable as proposed: it attempts to address a combination of material and energy efficiency, recyclability, use of renewable resources and product durability elements; this involves the use of financial measurement units that would themselves be problematic to apply in order to provide an understandable and relevant indicator. Further consideration needs to be given to the most effective indicator or indicators to address these elements, separately or in some combination.

XI. The Toxic Release Index as proposed would be difficult to use as a reliable and objective indicator because of its dependence on weighting factors for toxic substances and the current lack of scientific data and consensus about toxicity. Relevant indicators for toxic releases could nevertheless be devised, which could employ data already being recorded, tracked, and, in some jurisdictions (for example, the USA and Canada), reported to authorities as publicly accessible information.

Workshop participants recommended that work proceed to develop and pilot test eco-efficiency indicators according to the four levels of priority set out below. The suggestion was made that a more in-depth assessment of users' needs for information about eco-efficiency be carried out, so as to gain a more thorough understanding of the decisions that eco-efficiency indicators should be designed to inform.

1. Indicators for reduction of material intensity and of energy intensity

Workshop participants clearly agreed that these two elements of eco-efficiency are ones for which indicators are particularly relevant to many users, and can be readily implemented, subject to necessary definitions being developed and pilot testing being completed before wide-scale introduction in business. Materials efficiency and energy efficiency should be measured by separate indicators, however, and not combined in a single one.

Companies in several countries have already designed and implemented indicators relating to these elements of eco-efficiency. The next step therefore is to build on such work, develop consensus as to indicator design, and promote the wide acceptance, implementation and use of indicators for these elements.

2. Indicators for reduction of toxic dispersion

Development of one or more indicators for toxic dispersion or releases was also considered to be both highly desirable and relatively feasible, in view of the likelihood that toxic release data pertaining to specified substances is already routinely tracked and recorded by companies that are subject to existing domestic laws (in some countries) and international treaties (in many countries). 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 USA's Toxic Release Inventory or Canada's National Pollutant Release Inventory.

Further work was seen to be needed, however, to examine existing requirements and practices in defining, measuring and reporting releases of substances that are of concern, and in assessing and comparing their toxicity.

3. Indicators for enhancing material recyclability, maximizing sustainable use of renewable resources and extending product durability

Participants agreed that appropriate indicators in each of these three elements of eco-efficiency would be valuable, but that somewhat further consideration is required for clearer determination of users' needs and development of definitions and design parameters before pilot testing and broader adoption by business. Possibilities for indicators in these areas might include ones for renewable resource depletion or consumption, use of recycled materials, and recyclable content of products. The possibility of linkages with material intensity indicators was also noted.

4. Indicators for service intensity and lifetime product cost

An indicator to measure the service intensity of goods and services was considered to be more difficult to design and implement. A similar conclusion was reached regarding an indicator for lifetime product cost, which, by definition, might be more difficult to apply at the level of a whole organization.

Overall outcomes - the way forward

The workshop ended with summary remarks by Al Aspengren and Stuart Smith. Mr. Aspengren supported the conclusions and recommendations by participants, and expressed particular interest in the proposals for addressing toxic releases. He also noted the importance of not overlooking the social implications of designing and implementing eco-efficiency indicators, and their potential to assist companies in creating value, both economic and social.

Dr. Smith then summarized key characteristics and themes of the day, including the focus on practical, realistic and concrete action, the openness to consideration of new concepts and ideas, the willingness to listen, and the importance attached to soliciting and analysing data based on field experience. Above all, the workshop had clearly confirmed that efforts to develop a core set of eco-efficiency indicators should be continued.

Canada on its own, however, would not be able to carry out alone all the recommendations made by workshop participants. Future work would have to proceed on even more of an international basis and the NRTEE Task Force might need to be further broadened, perhaps becoming even more of a shared undertaking with other organizations and countries.

Successful progress will depend on continued gathering of experiences from companies in

different industries, and on building on the work of organizations in Canada, the USA and other countries regarding the design, implementation and value of eco-efficiency indicators.
Five or six volunteer companies from industry and also from the financial sector might be sought initially to pilot the implementation of new indicators on a volunteer basis for, say, a one year period. This might then be followed by piloting on a wider basis, the evaluation of which could provide valuable input to a second workshop to assess progress made and lessons learned, as well as other relevant developments in the business world since 1997.

1. Setting the stage

A. Workshop background and objectives

In the summer of 1996, Canada's National Round Table on the Environment and the Economy (NRTEE, see Appendix A for a summary of its mandate and membership) initiated a program to focus on eco-efficiency, and established a task force to give direction to that program.

The concept of eco-efficiency originated in the pre-Rio 1992 publication, "Changing Course", by what was then called the Business Council for Sustainable Development (BCSD). This concept was subsequently developed and promulgated internationally by the World Business Council for Sustainable Development (WBCSD, successor organization to the BCSD), centering around seven core elements, and defined in the 1995 publication by WBCSD, "Eco-efficient Leadership" (see Box 1).

> Box 1: Definition and Elements of Eco-efficiency
>
> "Long Definition":
>
> 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.
>
> "Short Definition":
>
> The goal is to create value for society, and for the company, by doing more with less over a life cycle.
>
> The seven elements of eco-efficiency:
>
> 1. Reducing the material requirements for goods and services
> 2. Reducing the energy intensity of goods and services
> 3. Reducing toxic dispersion
> 4. Enhancing material recyclability
> 5. Maximizing sustainable use of renewable resources
> 6. Extending product durability
> 7. Increasing the service intensity of goods and services.

At an early stage in its work, the task force identified eco-efficiency performance indicators as an important area to address. The need for such indicators had become evident from the interest shown by businesses themselves in assessing eco-efficiency, and increasingly by external parties such as financial institutions, legislators and customers. The NRTEE's task force concluded that development and implementation of a core set of indicators to measure, report and track companies' performance relative to the elements of eco-efficiency would be a significant contribution to advancing eco-efficiency in businesses of all types. The task force noted that many companies, for internal management needs or for regulatory reporting purposes, already measure aspects of their environmental performance, and that some do so in areas similar to or corresponding with one or more elements of eco-efficiency.

At present, there is a wide range of practices in environmental performance measurement and reporting. There is, however, no widely accepted consensus as to what aspects of environmental performance should be measured, nor as to the appropriate ways to carry out and report such measurement in a way that can provide more consistently relevant, reliable information and also facilitate benchmarking and comparisons between companies and over time. The elements of eco-efficiency, already a focus or pillar for strategic management in some companies, offer a framework around which to build consensus in designing and specifying a small, core set of performance indicators that all companies would use both for internal and for external reporting purposes. Such indicators would be used as a supplement to, not a replacement for, the broader range of indicators that companies and industry sectors already use for their more specific purposes.

The NRTEE therefore organized a workshop, sponsored jointly with the WBCSD, to explore in more depth the needs and possibilities for developing a core set of eco-efficiency indicators. To provide a common starting point for discussion, the NRTEE proposed three indicators that address certain elements of eco-efficiency, and commissioned the preparation of a background paper on the needs, issues and possibilities for eco-efficiency indicators. The executive summary of the background paper is provided in Appendix D of this report.

Accordingly, on Wednesday, April 2, 1997, leading representatives from industry, NGOs and government met by invitation in Washington, D.C., to discuss their experiences in measuring eco-efficiency within companies and, to the extent possible, reach conclusions on the feasibility of developing and implementing a core set of eco-efficiency performance indicators. These individuals came from organizations in Canada, the US, Mexico, Colombia and Switzerland; many had also worked extensively in other countries or were involved in work concerning developing countries; all are practitioners and thinkers in the areas of eco-efficiency, performance measurement and business policy.

The agenda for the workshop is set out in Appendix B, followed, in Appendix C, by a list of the participants and their organizational affiliations. Opening plenary remarks were followed by two extended periods for facilitated break-out group discussions on structured topics, culminating in a closing plenary session for sharing and seeking consensus on conclusions and recommendations. Particular emphasis was placed on focusing discussions and conclusions at a practical level, including making recommendations for prioritizing the types of indicators on which design, experimentation and development should proceed following the workshop.

Early in the plenary proceedings, participants were asked about their expectations for what the workshop might address and achieve, and any particular concerns they would like to see taken into consideration. Their replies are summarized in Box 2.

Box 2: Summary of Expectations and Concerns for the Workshop

Expectations:

Reach consensus on core set of indicators so as to set priorities, direction

Decide on paths forward that are achievable and flexible

Be practical as to useful next steps (measures that are implementable, even if not perfect)

- Build support for critical mass to make progress, reach broad consensus
- Address need to make performance comparisons between companies, and over time
- Make progress towards convergence on metrics (ones that are simple and understandable)

Aim for indicators that are consistent where possible with existing indicators, data

Not to lose sight of the context of sustainable development and socio-economic issues

- Strive for measures (rather than any single one) that
  - provide a concise synthesis/aggregated view of performance
  - can be integrated with other measures
  - link with financial measures and are relevant to capital market participants
  - are relevant to business strategy ("what gets measured gets managed")
  - are widely applicable across industries, including service sectors
  - are relevant to and can be implemented by SMEs
  - are relevant and can be implementable in other countries, not just North America
  - support decisions, lead to action
  - are relevant to "annual eco-reports"
  - are applicable in non-renewable resource sector industries

Concerns:

Caution - need to preserve scientific credibility, and not alienate the business community

- Initial focus should be on internal, management needs, not external disclosure requirements

Need to recognize the relationships between indicator selection and social values, and the implications of indicator selection for public policy goals

- Need to consider implications for regulatory oversight bodies and their policies
- Need to consider independent verification issues

The conclusions reached, recommendations made and directions for next steps are outlined in the remainder of this Scoping Report. Highlights of the plenary and break-out group sessions are also provided to assist readers in appreciating the flow of ideas and thoughts throughout the day.

B. Opening remarks at the workshop

Al Aspengren, for World Business Council for Sustainable Development

By way of setting the stage for the ensuing work sessions, the workshop opened with a presentation by Mr. Al Aspengren, Manager, US and International Eco-efficiency Programs, 3M. Mr. Aspengren is a member of the NRTEE task force on eco-efficiency, and is assisting the CEOs of Dow and 3M in writing a book on eco-efficiency soon to be published by WBCSD, of which both companies are members. The Chairman and CEO of 3M, Livio D. DeSimone, is the chair of the WBCSD.

This presentation reviewed developments in the relationship between business and sustainable development over the last decade, the evolution of the eco-efficiency concept over the last five years and the resulting definitions (see Box 1). Initiatives by 3M regarding sustainable development and eco-efficiency were reviewed, including the well-known 3M "Pollution Prevention Pays" principle, Life Cycle Management approach and Design for the Environment. Business gains from the value creation that eco-efficiency should promote, since, for example, maximizing resource productivity directly benefits the bottom line, which in turn rewards shareholders. Eco-efficiency is not a "business as usual" approach: it calls for a fundamental change of mindset if it is to be implemented in a way that ensures the desired "wins". A new stream of business literature and guidance is emerging, directed towards the successful implementation of eco-efficiency in businesses around the world, and there are now a number of useful guidelines on environmental performance measurement and reporting.

Dr. Stuart Smith, for the National Round Table on the Environment and the Economy

To complete the stage-setting, Dr. Stuart Smith, chair of the NRTEE and of its task force on eco-efficiency, offered his own expectations for the day as summarized below:

While NRTEE had put forward for consideration three possible eco-efficiency indicators, these were to be thought of as catalysts for fresh ideas, or springboards for more detailed practical discussion, and might be built upon or discarded as those present might deem appropriate.

Ultimately what is needed are a few robust, widely accepted, quantified and verifiable indicators that all companies would use - initially for management and board of directors' purposes, but also for external performance reporting as and when that may occur. The NRTEE's initiative was not driven by an intent to bring about new, mandatory external disclosure requirements.

Eco-efficiency indicators should be focused at the company or entity level (not at product or site levels), and should enable reliable comparisons to be made between companies in a given sector and over time. They are likely to have different values in different industry sectors, just as the values for financial performance indicators vary between sectors.

Trade-offs have to be made between simplicity and completeness: a preferred course would be to at least get started and move forward with whatever can most readily be implemented, regardless of whether all elements of eco-efficiency may immediately be measured or addressed by a single indicator.

Eco-efficiency represents a subset of sustainable development that may be more readily addressed within business agendas than the full spectrum of societal and public policy issues associated with sustainable development. Indeed, as one participant had observed, the very choice of what is measured and reported about corporate environmental performance can itself have broad social and public policy implications.

Finally, it is important to recognize that time constraints limit what can be achieved on such a complex topic within the duration of a one day workshop.

2. Broad considerations for developing eco-efficiency indicators

During the course of the workshop's plenary and breakout group discussions, a number of considerations and issues were identified regarding the development of eco-efficiency indicators in general. These are summarized below:

Voluntary and evolutionary development process. The process of development and implementation of eco-efficiency indicators should be voluntary and evolve over time, e.g., progressively address the elements of eco-efficiency, develop linkages to financial reporting and full life-cycle assessment and costing.

Socioeconomic issues and sustainable development. How do eco-efficiency indicators relate to the broader socioeconomic context, social issues and sustainable development? This raised questions as to whose values should be adopted and the differences between countries, as well as how to measure such values. Workshop participants generally agreed to limit the scope to eco-efficiency measures at present without also trying to incorporate social values in them.

Need for trade-offs. The need for trade-offs between simplicity and completeness in the eco-efficiency indicators was accepted, as was the need to move forward with imperfect measures and refine them over time.

Internal versus external use and reporting. A distinction was drawn between internal and external use and reporting of the indicators, i.e., providing information for managerial decision-making versus providing "auditable" or transparent numbers for external reporting purposes. The first step in the process should be to provide information for internal decision making.

Different users have different information needs. Different users will have different information needs and it will be necessary to determine who needs what information for what decisions in order to understand how the information will be used. The meaning of the indicators therefore must be transparent and clear to all the users of the information, such that the information may have to be tailored to meet the requirements of different audiences.

Eco-efficiency indicators are tools not drivers. Eco-efficiency indicators should not in themselves be the drivers or the goals for improved eco-efficiency, but rather should be tools for informed decision-making. In this regard, the process of goal-setting (by companies, industry sectors, society, etc.) and its relationship to the use of indicators should be examined.

Scope of indicators - life-cycle approach. To what aspect(s) of the life-cycle should eco-efficiency indicators relate? Indicators may relate to one or more aspects of the life-cycle ranging from resource extraction to production/plant processes to product use to disposal. Also in terms of scope, the indicators may be at the facility, plant, or company level or may be aggregated to reflect some combination of these. This relates to the issue of who are the users of the information, i.e., the indicators should allow opportunities for improved performance (both environmental and financial) to be identified by the appropriate decision makers.

Financial versus physical measures. The issue of whether to use financial or physical measures was raised. Although the use of financial measures more easily allows us to make linkages with existing financial measures and the financial reporting system, we do not yet adequately account for costs. In the absence of full cost accounting, the true costs involved will not be captured accurately. Measuring value and value-added is also a difficult endeavour and can be highly subjective.

Indicator characteristics. In terms of indicator characteristics, the pros and cons of using absolute versus relative and normalized measures, and physical or financial measures were discussed.

Develop an indicator for each element of eco-efficiency. The development of an indicator for each element of eco-efficiency (see Box 1) should be considered. However, the final four eco-efficiency elements may conflict with the first three, or may lead to perverse results in certain instances and it may not be possible to develop useful indicators for these last four elements. Furthermore, the fifth eco-efficiency element, sustainable resource use, may be misleading in that the renewable/non-renewable distinction can be misleading such that the scarcity of the resource also may need to be considered. In any event, the relationships between the various indicators developed and implemented will need to be tracked to avoid such outcomes.

Aggregation. Aggregating or "rolling up" performance indicators, either into a single overall index, or from individual products to the level of a company (e.g. for durability) can be problematic.

3. Eco-efficiency indicators – discussion and proposals

The main focus of the workshop, particularly the deliberations of the three working groups in their break-out sessions, was to discuss the NRTEE's three proposed indicators - the Resource Productivity Index, the Product and Disposal Cost to Durability Ratio and the Toxic Release Index. This section of the Scoping Report summarizes the results of these deliberations, including key points and consensus views, modifications proposed, linkages to other indicators and suggestions for next steps to advance indicator development and implementation.

A. Resource Productivity Index (RPI)

The resource productivity index was proposed in order to express as a percentage the materials and energy contained in a company's products, by-products and useable wastes as compared to the materials and energy consumed in their production. This indicator addresses the first two elements of eco-efficiency and would allow companies to evaluate their performance over time to determine whether they are improving their resources and energy productivity. (Backgrounder, pp. 27-28)

$$\text{Percentage} = \frac{\text{Product out (matter plus energy)}}{\text{Energy in + Matter in}} \times 100$$

Some of the limitations of the indicator recognized in the Backgrounder include the difficulty of defining common measurements for materials and energy and of distinguishing between products, by-products and wastes.

Discussion: key points and consensus views

In general terms, the intent of the RPI was supported by all the workshop groups. Its elements were believed to be measurable and its results would allow for comparison between the products and services of companies. The need for simplicity in the development and implementation of the indicator was considered to be very important.

However, as a result of the difficulty of equating mass and energy, consensus was reached that the materials and energy portions of the equation, although linked, need to be separated and that two indices, one for materials productivity and one for energy intensity, should be created.

More specific points raised about the RPI included:

- the scope or boundaries of the indicator must be defined, e.g., should the RPI apply to the entire life-cycle of a product, or should it be restricted to its production or manufacturing processes, at least initially.
- the terms products, by-products and wastes need to be clearly differentiated and defined.
- the various components of the formula may need to be weighted in some manner, for example, to reflect the relative advantages and disadvantages of using renewable or non-renewable sources of energy and recyclable or non-recyclable products, as well as the relative toxicities, if any, associated with the materials and energy used and generated. For example, the possibility that increasing the efficiency of raw material use could result in an increase in toxic releases should be considered. A proposal also was made to value products and by-products equally.
- the concepts of value-added and social costs were discussed in terms of how they could be included in the calculation, but no practical conclusions were reached.
- consideration should be made of the use of long-term rather than short-term

measurements in calculating the RPI.

- linkages between the RPI as a physical measure and relevant financial performance measures should be considered.
- the role of packaging in the indicator should be determined, and the definitions of product and by-product need to address packaging.

Proposed modifications

The following two indices were proposed to separate the RPI into its two components.

Material productivity index (eco-efficiency element #1)

$$\frac{\text{weight of product and weight of by-product out}}{\text{weight of material in (recycled + raw materials)}} \times 100$$

Alternatively, the material productivity index could be expressed as a ratio rather than as a percentage. The result in both formulations would provide an indication of the amount of waste generated or released in the creation of a product.

Energy intensity index (eco-efficiency element #2)

Two versions of this indicator were proposed by one group as follows:

(i) On a company-wide basis

joules/product unit or service

Alternatively:

$$\frac{\text{energy generated by product}}{\text{energy consumed in product}} \times 100$$

(ii) On a sector-wide basis

joules/product unit or service

Linkages to other indicators

The RPI may be linked to the proposed toxic release index (see below) in that different energy or material sources and production technologies have different associated toxicities and/or toxic emissions. As noted above, the resulting environmental impacts might be factored in by weighting or reflected in some other manner in the index calculation to the extent possible. Concerns about the practical difficulties of "weighting" were noted, especially regarding the need for comparability and consistency. (The toxic release index could be modified as a measure focusing on one stage of the life-cycle, i.e., a "slice" of the RPI.)

Both the materials productivity and energy intensity indices could be subdivided or broken down further into specific material and energy types, e.g., the materials index could be partitioned into types of resources, such as water, and the energy index could be divided according to use of renewable and non-renewable energy. Weightings could then be applied to each in order to arrive at an aggregate material index and an aggregate energy index.

Note: Monsanto has developed a computer simulation model for analyzing the energy, materials and emissions of its products over their full life-cycle. The results can be aggregated into one or more measures.

What needs to be done to advance development and use of the indicator(s)

In terms of design:

- Consider materials and energy separately, as well as even more specific RPI indicators within each, e.g., for renewable and non-renewable energy and materials.
- Clarify the scope of application of the indicator, i.e., full life-cycle or limited to production/manufacturing processes or some combination of the life-cycle stages including resource extraction, procurement, manufacturing processes, production, product use and disposal, as well as the level of application, i.e., facility, plant, company, industry sector, etc.

Note: The general consensus was to adopt a staged approach, starting with a more limited focus both in terms of the life-cycle and level of application and extend or broaden the scope over time. An advantage of using a narrower level of application initially (e.g., taking measures at the site level) is that it will allow decision-makers to identify opportunities more easily, whereas using an indicator based on higher level measurements might obscure such opportunities. This approach might also encourage more companies to participate, both large and small.

Define product, by-product and waste appropriately.

- For the material productivity index, determine whether a value-added component can and should be incorporated into the indicator.
- Consider the treatment of packaging in the materials equation.
- Examine the weighting issue further, e.g., for the use of virgin rather than reusable or recyclable materials and renewable, scarce or non-renewable materials and energy.
- Explore the use of financial values for the indicators and consider whether socio-economic costs/values can be brought into the equation.
- Explore possible linkages to public policy.

In practical terms:

To move forward with the two modified RPI indicators, the following steps were suggested:

1. Examine existing applications by companies to determine whether such measures (or other similar measures) are being used. Consider/evaluate the results of their use to determine the applicability of the proposed indicators and who are the users and audiences of the information. Also, some companies may have developed software models for calculating materials productivity.
2. Test the proposed indicators on a limited pilot basis with volunteer companies and organizations.
3. Based on the results of the initial pilot project, extend to a broader group for further field testing.

B. Product and Disposal Cost to Durability Ratio (PDCDR)

The product and disposal cost to durability ratio was proposed as a means of incorporating the concepts of product stewardship and durability in a single measure by expressing the cost of a product as the sum of its purchase price and disposal cost divided by its years of life. An alternative formulation would include the cost of using the product over its lifetime in terms of the energy and materials consumed.

$$\text{Ratio} = \frac{\text{Purchase price} + \text{Disposal cost}}{\text{Years of life}}$$

Or:

$$\text{Ratio} = \frac{\text{Purchase price} + \text{Cost of energy and/or materials used} + \text{Disposal costs}}{\text{Years of life}}$$

Challenges posed by the indicator include appropriately defining and measuring in monetary terms the components of the equation. For example, the purchase price is intended to serve as a proxy for all the costs incurred in producing the product, and the disposal cost is intended to reflect the true costs of disposal less the value of recycling or reuse of the product. The years of life denominator also needs clear definition, e.g., "designed useful life". An additional factor for consideration is the time value of money. (Backgrounder, pp. 29-30)

Discussion: key points and consensus views

Much less support existed for this indicator as a useful or compelling metric for eco-efficiency, due primarily to its limited applicability to the concept of eco-efficiency, the difficulty of making accurate calculations in the absence of full cost accounting, and the emphasis on durability at the expense of factors such as recyclability and the need for innovation to create better products. It was considered to be more applicable, if at all, to products than to a company as a whole. The overall consensus was that the indicator needs to be substantially reworked if it is to be pursued further in this process, in other words, "back to the drawing board".

The following is a summary of the key points made about the PDCDR:

- it is essentially a financial indicator of life-cycle costs that could be used as an input to eco-efficiency, but it is not very useful or powerful in terms of actually promoting or measuring eco-efficiency. Furthermore, the indicator is not immediately understandable or transparent.
- it is of limited application to industry, in that it is primarily applicable to the hard goods sector, although it might be possible to consider using the indicator in terms of the capital investment life-cycle for capital-intensive industries. Alternatively, as discussed immediately below, the PDCDR could be used as an indicator of lifetime product costs at the community or consumer/household level. As such, it would resemble a consumer eco-label or consumer financial index.
- it is difficult for companies to allocate disposal costs precisely to particular products, furthermore, these costs are extremely variable between jurisdictions as well as over time within a jurisdiction. Finally, in the absence of adequate full cost accounting techniques and methodologies, these costs cannot be calculated accurately so as to be meaningful.
- as a measure of durability, the indicator results may conflict with recyclability in some cases. The emphasis on durability also may stifle innovation for products that are more eco-efficient, and it disregards the value of convenience. Increasing durability may also increase disposal costs. There are important but complex linkages between durability, recyclability and societal values.
- the indicator raises difficult life-cycle issues in terms of accurately costing its components over the life-cycle of a product.
- the role of packaging needs to be considered in the equation.

Proposed modifications

The following modifications to the PDCDR were suggested:

- use of the manufacturers' gate price is preferable to using the purchase price.
- the concept of durability (the years of life denominator) should relate to the "useful life" of the product rather than to its actual life. (For example, a car's durability would be calculated as the number of years it functions efficiently in terms of gas consumption, etc.) Alternatively, the concept of the adaptability of a product might be considered as a relevant factor in the equation.
- the RPI proposed in the preceding section could perhaps be extended to encompass this indicator by using a full life-cycle for its measurement.

The following alternative indicator was proposed by one group for use at the community or consumer/household level.

Lifetime cost index (eco-efficiency element #6)

To allow consumers to make comparable material choices and to reflect the customer cost of ownership and notions of extended product stewardship, the lifetime cost index could be expressed as the following equation:

Purchase price + Useful life cost of energy and/or materials + Disposal cost Years of life

To address the potential conflict between durability and recyclability, one group proposed development of a separate measure for each.

Durability index (eco-efficiency element #6)

This indicator would provide information about the service/useful life of product on a product/by-product basis, by reporting how long products last based on the materials used in their production. It also could be merged with the following indicator.

Material recyclability index (eco-efficiency element #4)

This indicator would report on the amount of recyclable material in a product and/or the amount of material actually recycled.

Linkages to other indicators

In terms of the PDCDR as proposed, an extended or revised version of the RPI may be able to incorporate some of its key elements, thereby avoiding the need to rework the indicator completely. As noted above, the proposed lifetime cost index may have useful linkages with eco-labeling schemes and consumer financial indices. There was concern about trying to load too much into a single indicator.

What needs to be done to advance the development and use of the indicator(s)

As noted above, the indicator as currently envisaged needs to be reworked before it can be pursued as a feasible option. With respect to the alternative indicators proposed, the following steps could be taken:

Lifetime cost index

- Determine and define its applicability and scope.
- Partner with consumer organizations for actual development and implementation of the indicator.
- Evaluate and possibly integrate the indicator with eco-labeling and extended product stewardship schemes.

- Pilot test use of the indicator.

For both the durability index and the material recyclability index, their feasibility needs to be investigated and explored, their details need to be fleshed out and their numerators need to be determined. Means of combining or merging the two indicators based on years of use should also be considered.

C. Toxic Release Index (TR Index)

The toxic release index was proposed to express as a single number the amount of toxic materials released during the manufacture of a product, or during a given operating period, calculated as the sum of the adjusted masses (weights) of each toxic material released.

Total mass = (TS1M x TS1WF) + (TS2M x TS2WF) + (TS3M x TS3WF) + ... etc.

Where:

TS1M = Toxic substance 1 mass

TS1WF = Toxic substance 1 weighting factor

Key challenges to the use of this indicator are the difficulty of assigning the appropriate weights to the toxics and of selecting the substances to be regarded as toxics. (Backgrounder, pp. 30-31)

Discussion: key points and consensus views

The importance of measuring toxics was universally agreed upon and strong support in principle existed for this type of indicator. This support was bolstered by the existence of regulatory reporting requirements and data measurement, collection and recording methods for toxic emissions. Another positive characteristic of the indicator is that its results would allow for comparison in performance over time and between companies.

However, the TR index poses serious problems with respect to the definition, quantification and weighting of toxics, each of which may involve highly subjective processes. To date, no satisfactory validation exists for the toxicity measures that constitute the basis of the indicator. The notion of clustering groups of toxics, using a small number of descriptors, was proposed as a more feasible alternative to assigning a unique toxicity factor to each toxic. A similar, but simplified approach would address chemicals at two levels: (1) persistent, bioaccumulative and toxic, and (2) risk-managed (dosages), with weightings/priorities assigned at each level.

Additional shortcomings identified with the TR index included the difficulty of accurately allocating quantities of toxics in processes in which different types of products are made, and the omission of the important concepts of exposure and dosage in the equation.

More specific key points raised relating to the TR index were:

- an alternative approach to measuring the quantity of toxics [which to some degree is already addressed by regulatory reporting schemes such as the US Toxic Release Inventory (TRI) and Canada's National Pollutant Release Inventory (NPRI)] could be to estimate their potential effects on a site or company-specific basis. This approach would include consideration of pathways, exposure, and effects on different organisms, as well as transport and fate (media/multi-media). For example, Monsanto uses a three-factor formula to measure the potential effects of toxics:

hazard (human effects + effects to other animals + phytotoxicity) X cube root of the mass of

release (to address dispersion) X media factor (to address pathways and exposure via the pathways).

- in some respects, the TR index is not an indicator proper, but rather is a tracking or recording system for toxic releases, and as such could be subcategorized according to amounts of toxics released, disposed, destroyed or recycled. A separate category could provide information about toxics spilled. Data currently exists in the form of regulatory reporting schemes for toxic emissions and spills that would facilitate further development and use of such an indicator or indicators. However, one limitation of adapting a US TRI-type reporting scheme is that no weightings are applied, such that reportable quantities are the same for all chemicals (although spill reporting schemes in the US do have several levels depending on toxicity).
- the TR index might be more useful as a broad tool for identifying "red flags", rather than as a precise indicator.
- the aggregation proposed by the TR index can provide a useful relative measure and establish trends over time (in addition to the absolute measures that currently exist with the US TRI and NPRI in Canada). On the other hand, such aggregation may conceal important information.
- the issue of inherent toxicity versus actual risk (risk assessment approach) should be addressed, as should the need to consider and include product use or product dispersion where products are toxic (e.g., pesticides, fertilizers). Similarly, indicators for hazardous products that are not toxic also should be considered.
- in terms of the toxic dispersion eco-efficiency element, and as with the previous two indicators proposed by the NRTEE, the issue of which aspects of the life-cycle should be included in the indicator needs to be addressed.

Proposed modifications

One group proposed the following two-part strategy to modify the TR index:

- adopt a virtual elimination strategy for the thirteen priority chemicals recognized on international lists, and report progress in eliminating these chemicals, e.g., as a percentage of reduction in terms of set goals/targets, assuming a base year is established. No weightings would be needed and the results could be compared between companies. The first implementation step would be to aggregate the mass loading. The results could also be normalized, e.g., per $1,000 revenue (see the Emissions Efficiency Index® used by the Investor Responsibility Research Center - IRRC).
- address other priority chemicals based on their toxicity, bio-accumulation and persistence (e.g., chemicals that are reportable under the US TRI and the NPRI), by relating the tonnage released per unit of product or service. Total releases could be measured in mass on a company, geographic, national or other basis with the goal being reduction over time. The results could be normalized as in (1) above.

Results from (1) and (2) could be combined to create one aggregated indicator using the following equation:

Mass of 13 chemicals (higher weighting?) + mass of other priority chemicals
$ value (or unit of product or service)

Other suggested modifications to the proposed TR index were:

- report on toxic emissions according to specific media, e.g., air, water, etc.
- develop a methodology for weighting toxics, but allow companies to assign the actual weights themselves (this clearly would reduce comparability however).
- refine the RPI to focus on toxic emissions, such that the toxic component of the total mass released is calculated to supplement existing toxic regulatory reporting requirements.

Alternative indicators suggested were:

- the number or quantity of spills
- emission compliance rates
- percentage of emissions/spills above legally allowable levels.
- normalize the US TRI and NPRI results similar to the IRRC Emissions Efficiency Index® referred to above.

Linkages to other indicators

As noted above, the TR index has linkages to existing reporting frameworks for toxic emissions such as the US TRI and the NPRI and ARET (Accelerated Reduction and Elimination of Toxics) in Canada, and as such could be used to supplement these absolute values. Alternatively, the TR index could be characterized as a segment of the RPI that focuses on toxic emissions.

What needs to be done to advance the development and use of the indicator(s)

The following actions steps were proposed:

- Define the scope of the indicator and reach consensus on the list of specific chemicals (using existing lists and agreed-upon criteria where possible).
- Consider using a phased approach to implementation (see the two-part approach described above).
- Review existing models/methodologies for measuring toxicity and for reporting on toxic emissions, e.g., industry efforts including Monsanto's potential effects model.
- Build on existing infrastructure developed for reporting under the US TRI, Canada's NPRI, etc. Consider developing a model to supplement legislated reporting for use as a prioritizing tool.
- Conduct field trials.
- Analyze results and engage in further discussion and trials.

D. Other indicators to consider

Other possible indicators were considered to address elements of eco-efficiency not adequately incorporated into the three proposed measures for eco-efficiency. This resulted in the following suggestions to address the sustainable use of renewable resources and service intensity elements of eco-efficiency.

(a) Sustainable use of renewable resources

In terms of measuring the sustainable use of renewable resources, two concepts were discussed: process inputs and a depletion index.

Process inputs

After separating process inputs into renewable and non-renewable resources, this indicator would involve calculating the percentage of renewable materials and the percentage of renewable energy inputs in a production process. The renewable/non-renewable ratio as a percentage of the total materials and as a percentage of the total energy could be calculated as two separate measures. The indicator could be related to material recyclability. Issues to be addressed are the distinction between virgin and recycled materials (should virgin non-renewables be treated differently from recycled) and the notion of scarcity (should a scarce renewable resource be

treated differently from an abundant non-renewable resource, for example).
Depletion index
The depletion index would be calculated as follows:

% of Renewable Resources in Product (including recycled, reclaimed, reused) % Virgin Material

This index would not apply to energy inputs or to non-renewable resources in the short term.
(b) Service intensity of goods and services
An indicator for the service intensity of goods and services would reflect the amount of functional use per unit of product or service:

Use Unit of Product or Service

Or:

Energy or Material Inputs Unit of Product or Service

Efforts also were made to determine how to measure the value of a product, e.g., in terms of multiplicity of uses or longevity of service life. An indicator might be developed to reflect the value or function delivered by a product according to its effective mass or energy, based on the percentage of recyclable or reusable mass or energy:

Product Value Effective Mass or Energy

What needs to be done to advance the development and use of the indicator(s)
Each of the proposed indicators described above requires further work in terms of definitions, scope and conceptual refinements prior to implementation on a trial basis.
4. Conclusions and recommended next steps
The reports to the plenary sessions of the workshop by the three break-out groups revealed a clear consensus as to the indicators that should be developed and pilot tested, and the order of priorities for advancing this work.

A. Conclusions
The workshop participants reached the following consensus regarding the indicators originally put forward by the NRTEE (and described in the Backgrounder):

- The Resource Productivity Index, important in concept, should deal separately with materials intensity or efficiency, and energy intensity or efficiency.
- The Product and Disposal Cost to Durability Ratio is unworkable as proposed: it attempts to address a combination of material and energy efficiency, recyclability, use of renewable

resources and product durability elements; this involves the use of financial measurement units that would themselves be problematic in order to provide an understandable and relevant indicator. Further consideration needs to be given to the most effective indicator or indicators to address these elements, separately or in some combination. A number of suggestions are made below.

- The Toxic Release Index as proposed would be difficult to use as a reliable and objective indicator because of its dependence on weighting factors for toxic substances and the current lack of scientific data and consensus about toxicity. Relevant indicators for toxic releases could nevertheless be devised, which could employ data already being recorded, tracked, and, in some jurisdictions (for example, the US and Canada), reported to authorities as publicly accessible information.

From these overall conclusions flow the more following, more detailed conclusions and recommendations, grouped according to the broad priority rankings assigned by the workshop participants as a whole.

First Order of Priority:

Indicators for reduction of material intensity and reduction of energy intensity

Workshop participants clearly agreed on these two elements of eco-efficiency as being ones for which indicators are particularly relevant to many users, and can be readily implemented, subject to necessary definitions being developed and pilot testing being completed before wide-scale introduction in business. Materials efficiency and energy efficiency should be the subjects of separate indicators, however, and not combined in a single one.

Companies in several countries have already designed and implemented indicators for reduction of material intensity and of energy intensity. The next step therefore is to build on such work, develop consensus as to indicator design, and promote the wide acceptance, implementation and use of indicators for these elements. Moreover, as was noted in at least one break-out group, emerging international consensus around the need for action regarding human activities that may influence climate change might help build support for the widespread use of an appropriate energy efficiency indicator.

Second Order of Priority:

Indicator for reduction of toxic dispersion

Development of one or more indicators for toxic dispersion or releases was also considered to be both highly desirable and relatively feasible, in view of the likelihood that toxic release data pertaining to specified substances is already routinely tracked and recorded by companies that are subject to existing domestic laws (in some countries) and international treaties (in many countries). 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 US'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.

Third Order of Priority:

Indicators for enhancing material recyclability, maximizing sustainable use of renewable resources and extending product durability

Participants agreed that appropriate indicators in each of these three elements of eco-efficiency would be valuable, but that somewhat further consideration is required for clearer determination of users' needs and development of definitions and design parameters before pilot testing and broader adoption by business. The possibilities for indicators in these areas might include ones for renewable resource depletion or consumption, use of recycled materials, and recyclable content of products. The possibility of linkages with material efficiency or intensity indicators was also noted.

Fourth Order of Priority:

Indicators for service intensity and lifetime product cost

An indicator to measure the service intensity of goods and services was considered to be more difficult to design and implement. A similar conclusion was reached regarding an indicator for lifetime product cost, which by definition, might be more difficult to apply at the level of a whole organization.

B. Recommended next steps

Participants recommended that work should therefore proceed along the lines suggested by the break-out groups to pursue the development and piloting of eco-efficiency indicators in accordance with the priorities set out above.

It was also suggested that as one component of this work it would be valuable to develop a clearer, shared understanding of which users' needs are to be addressed, and what types of decisions, such as investment decisions both by boards of directors and by capital market investors, are intended to be informed and influenced by eco-efficiency indicators.

Such an understanding would guide future efforts to develop appropriate indicators, and efforts to communicate effectively with the various user groups about the purpose, implementation and interpretation of the indicators and information that are designed and advocated. The development and sharing of this understanding of needs and drivers might require the involvement not only of those who participated in the workshop, but also of other stakeholders, possibly on a sector-by-sector basis.

A further workshop-style session was suggested as one possible step in developing this clarification of users' needs and drivers. A matrix could be a helpful tool for such a process, with the elements of eco-efficiency on one axis and selected industry sectors on the other, as a framework to examine and compare the applicability of the eco-efficiency elements (and related indicators) across the sectors, and thus determine those indicators that have general applicability versus those having sectoral applicability.

5. Overall outcomes of the workshop - the way forward

In his closing remarks, Al Aspengren supported the conclusions and recommendations reported from the break-out groups, with particular interest in the proposals for addressing toxic releases, but noted the importance of not overlooking the social implications of designing and implementing eco-efficiency indicators, and their potential to assist companies in creating value, both economic and social.

Dr. Smith summarized several key characteristics and themes of the day, including the

- high level of energy and interest shown throughout by all present;
- focus on practical, realistic and concrete action;
- openness to consideration of new concepts and ideas, and the willingness to listen; and
- importance attached to soliciting and analysing data based on field experience.

However, Canada on its own would be incapable of carrying out in full the recommendations made. Future work would have to proceed on even more of an international basis, and the NRTEE Task Force would need to be broadened, perhaps become even more of a shared

undertaking with other organizations and countries, and to build on other initiatives.
Five or six volunteer companies from industry and also from the financial sector might be sought initially to volunteer to pilot the implementation of new indicators over, say, a one year period. This might be followed by piloting on a wider basis, the evaluation of which could provide valuable input to a second workshop to assess progress made and lessons learned, as well as other relevant developments in the business world since 1997.
In the more immediate future, ways and means would be explored to pursue the recommended process to focus on the needs of internal and external decision makers for eco-efficiency indicators and information. Continued gathering of experiences from companies in different industries, building on the work of the organizations and other countries and engaging in partnerships with them, will be essential for successful progress.

Appendix A: National Round Table on the Environment and the Economy — Mandate and Membership

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's State of the Debate reports synthesize the results of stakeholder consultations on potential opportunities for sustainable development. They summarize the extent of consensus and reasons for disagreement, review the consequences of action or inaction, and recommend steps specific stakeholders can take to promote sustainability.

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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Appendix B: Eco-efficiency Measurement Workshop
April 2, 1997
Washington, DC
Sponsored by: National Round Table on the Environment and the Economy & World Business Council for Sustainable Development
Agenda

08:00 - 08:30	Welcome and introductions
08:30 - 08:50	The concept of eco-efficiency Mr. Allen Aspengren, Manager, US and International Eco-Efficiency Programs, 3M Environmental Technology and Safety Services
08:50 - 09:10	Objectives of the workshop Dr. Stuart Smith, President, Philip Utilities Management Corp. and Chair, National Round Table on the Environment and the Economy
09:10 - 10:00	Opening plenary
10:00 - 10:20	Working session set-up and group organization
10:20 - 12:30	Working sessions on measurement and next steps
12:30 - 13:30	Lunch and recap
13:30 - 16:00	Working sessions, continued
16:00 - 17:00	Results sharing and next steps
17:00 - 17:15	Concluding remarks
17:15	Reception

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Appendix D: Backgrounder Executive Summary

1. Introduction

The National Round Table on the Environment and the Economy's (NRTEE) eco-efficiency task force is exploring the possibility of developing a system of performance indicators that would encourage companies to set measurable eco-efficiency targets, assist in assessing progress and performance against their targets, and facilitate comparisons of eco-efficiency1 performance between companies of all types and sizes, as well as within industry sectors. This paper is intended to support and inform a collaborative and consultative process to explore the feasibility of this proposal. The paper proposes the hypothesis that it is desirable and possible to develop a core set of performance indicators that could be used by businesses to evaluate their progress toward achieving eco-efficiency objectives and targets and to measure their overall eco-efficiency. These indicators would be used by both internal users such as boards of directors and management, and external users such as investors, lenders, governments, suppliers, customers and communities. They would also be used in conjunction with other financial and non-financial performance indicators, including industry-specific eco-efficiency indicators and absolute measures, to provide comprehensive performance information.

2. Eco-efficiency measurement: users, needs and drivers

There exists a broad range of users of and needs for eco-efficiency performance information, both within and outside a company. Drivers for needing this information are also varied. For example, drivers for directors and management are cost-savings, risk reduction, improved competitiveness and a recognition of accountability to all stakeholders; capital market drivers are longer-term profitability and risk minimization; regulators/government drivers are trade, environmental policy and international forces; and drivers for other stakeholders (e.g., suppliers, customers, communities, employees and ENGOs) are credibility and concern for sustainability. Thus, although the concept of eco-efficiency may not be familiar to all companies, in practice its principles are widely accepted.

As a result of these information needs and drivers, many companies have developed and implemented environmental performance measurement systems to meet their environmental and eco-efficiency goals and objectives. However, many different measures are being used, and they are not readily comparable. A unique challenge in developing eco-efficiency indicators, therefore, is to identify a few key indicators that may be used to measure eco-efficiency across all companies.

3. Eco-efficiency indicator selection criteria

Identification of guiding principles or criteria will be of value in developing a set of effective eco-efficiency performance measures. Based on a review of current practice and experience, nine criteria are proposed for use in designing, selecting and assessing eco-efficiency indicators: indicators should (1) address elements of eco-efficiency, (2) be simple and understandable, (3) be appropriate to users' needs, (4) be measurable and cost-effective to produce, (5) facilitate tracking of performance against objectives and over time, (6) be comparable between business entities and sectors, (7) be transparent and neutral, (8) be reliable and representative of the performance aspect being measured, and (9) be verifiable.

4. Environmental performance indicators in use today

There is a proliferation of environmental performance indicators currently in use, each measuring different aspects of environmental performance and each using different metrics and measurement units. Various organizations around the world have attempted to classify or categorize environmental performance measures and indicators in logical and orderly frameworks.

Environmental performance indicators currently used by companies to measure and report on their environmental performance may be of value in developing a core set of indicators. Examples provided in the paper because of their relevance to eco-efficiency are Novo Nordisk's Eco-Productivity Index, Nortel's Environmental Performance Index, Niagara Mohawk Power's Environmental Performance Index, British Telecom's Environmental Performance Index and Elf Atochem's Waste and Water Indices. Reference is also made to indicators used by Dofasco, WMC, The E.B. Eddy Group, the Investor Responsibility Research Center, and the UNI-Storbrand Scudder Stevens Fund, as well as to Monsanto's Sustainability Index and Ontario Hydro's Resource Utilization Index, both under development.

Several conclusions can be drawn from the examples given. First and foremost, analysis reveals that the broad types or classes of indicators currently in use around the world meet a number of important criteria such as relevance to eco-efficiency objectives, appropriateness to users' needs, measurability, understandability, verifiability and comparability in tracking performance over time. Limitations identified include complexity and lack of transparency in some instances, and difficulty of comparison, largely as a result of selectivity and subjectivity, and loss of reliability when information is aggregated. The effects of subjectivity, judgment and bias in a weighting scheme, uncertainty in measurement and differences between products and operations are compounded when information is aggregated, indexed or normalized. Some of these limitations may be more problematic in the process of compiling, synthesizing and condensing a large amount of information. A core set of indicators may need to be supplemented by the use of industry-specific benchmark values for these indicators, as well as by absolute measures of performance. Industry-specific eco-efficiency indicators may also be necessary.

5. Toward a core set of eco-efficiency indicators

Three eco-efficiency indicators have been proposed by the NRTEE as a starting point from which to focus and stimulate discussion at a practical level for developing a core set of such indicators: (1) resource productivity index, (2) product and disposal cost to durability ratio, (3) and toxic release index. The resource productivity index aims to express as a percentage the materials and energy contained in a company's products, by-products and useable wastes compared to the materials and energy consumed in their production. This indicator would allow companies to evaluate their performance over time to determine whether they are improving their resource and energy productivity. It does, however, pose challenges, such as defining common measurements for materials and energy. The product and disposal cost to durability ratio relates to product stewardship and recyclability, and expresses the cost of a product as the sum of its purchase price and disposal cost divided by its years of life. It too poses challenges, such as the creation of acceptable definitions for these terms. The toxic release index aims to express as a single number the amount of toxic materials released during the manufacture of a product, or during a given operating period, calculated as the sum of the adjusted masses (weights) of each toxic material released. This will require means for assigning appropriate weights to these toxics.

The proposed indicators are not fully developed and are in need of further analysis, debate and refinement. Although they meet a number of the proposed criteria, they also present a number of challenges. Nonetheless, they serve as a useful starting point for discussion and development.

6. Conclusion: challenges, benefits and opportunity

On balance, the proposition that well-designed indicators can be implemented to measure and report on aspects of a company's eco-efficiency in a meaningful way is supportable. The focus now should be to determine which and how many such indicators are needed to provide information that meets the selection criteria. Key challenges and potential benefits will need to be considered.

Challenges: (1) Significant and relevant information is often overlooked or concealed when a large amount of information is synthesized, and is therefore not reflected in the final measure, such that excessively composite performance indicators may not provide a balanced or useful picture. (2) Similarly, aggregation may result in loss of important information and, where measurements are imprecise or subjective, the accuracy and reliability of aggregated information is significantly reduced and may be difficult to verify. (3) In addition, measurement difficulties may exist when large amounts of diverse information are measured and aggregated. (4) Other problems are that weighting schemes involve subjective or value judgments; indices may be imprecise due to consolidation; and normalization, an important comparative tool allowing for direct tracking of progress and adjustments for production levels, may produce different and even misleading information depending on the unit of normalization chosen. (5) The criterion of comparability is difficult to meet where many variables and different combinations and permutations are being compared.

Benefits: (1) Core eco-efficiency indicators would, as with financial performance indicators, be understandable, succinct and universally recognizable, enabling them to serve as powerful decision-making tools providing important performance information at a glance. (2) The use of a core set of indicators also would result in consistency over time, despite any imperfections in the measures. To ensure consistency, common procedures for measuring, weighting and reporting will need to be developed. (3) Similarly, comparability, at least with respect to generic aspects of environmental performance, would be extremely useful. (4) Finally, the indicators will meet the criterion of transparency if they are developed and implemented through consensual and educational multistakeholder processes that allow them to gain acceptance by a wide range of audiences and users.

Opportunity: The opportunity exists to build on the work and ideas of companies and others to develop a core set of eco-efficiency indicators that can serve as a common performance measurement language – one that crosses industry sectors and international boundaries, and complements other types of performance information needed by businesses and their stakeholders.