



BizNGO Chemical Alternatives Assessment Protocol



How to Select Safer Alternatives to Chemicals of Concern to Human Health or the Environment

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The Business-NGO Working Group promotes the creation and adoption of safer chemicals and sustainable materials in a way that supports market transitions to a healthy economy, healthy environment, and healthy people.

Acknowledgments

The BizNGO Chemical Alternatives Assessment Protocol builds upon the work of thought leaders in substitution and alternatives assessment, including the: Lowell Center for Sustainable Production, U.S. Environmental Protection Agency's (EPA's) Design for the Environment (DfE) Program, United Nations Environment Programme–Stockholm Convention on Persistent Organic Pollutants, Massachusetts Toxics Use Reduction Institute, Interstate Chemicals Clearinghouse, ChemSec, Kooperationsstelle Hamburg, and Ökopol.

In December 2010, at the 5th annual meeting of BizNGO, a provocateur in the audience challenged us to take up the task of defining best business practices in selecting safer alternatives to chemicals of concern. In 2011, BizNGO participants formed an ad hoc working group to support the creation of the Protocol and met over the course of a year to offer ideas, criticisms, and revisions. We are particularly indebted to Dennis McGavis of Shaw, Helen Holder of HP, and Howard Williams of Construction Specialties for their insights informed by alternatives assessment practices in their own companies. Sally Edwards of the Lowell Center and Cal Baier-Anderson, Kathy Hart, and Libby Sommer of U.S. EPA's DfE Program all made invaluable contributions based on their own extensive work with alternatives assessments. Finally we are grateful to Alex Stone, Chris Youssef, Joel Tickner, Ken Geiser, Peter Syrett, Rich Liroff, Tom Lent, Topher Buck, and Tracey Easthope for their detailed and thoughtful review of this paper.

We take full responsibility for any flaws or omissions in this Protocol. Note that being a reviewer of the Protocol does not equate with endorsement of the Protocol. We view the BizNGO Chemical Alternatives Assessment Protocol as an evolving process and welcome suggestions to improve it. For more information contact Mark@CleanProduction.org.

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BizNGO is a collaboration of leaders from businesses, environmental organizations, government agencies and universities. Our mission is to promote the creation and adoption of safer chemicals and sustainable materials in a way that supports market transitions to a healthy economy, healthy environment, and healthy people. Established in 2006, BizNGO is a project of Clean Production Action. For further information go to www.BizNGO.org.



Clean Production Action's mission is to design and deliver strategic solutions for green chemicals, sustainable materials and environmentally preferable products. Critical to our success is working closely with existing networks across the globe, developing new partnerships, learning about emerging technological trends and associated environmental health problems, and developing and communicating essential solutions. For further information go to www.CleanProduction.org.

Introduction

Businesses are under increasing pressure from governments and consumers to reduce the environmental and human health impacts of their products. Leading manufacturers are innovating to use inherently safer chemicals in their products. They recognize that reducing their reliance on chemicals of concern to human health and the environment meets market demands, keeps them ahead of regulations, reduces costs, and creates innovative and inherently safer products.

The *BizNGO Chemical Alternatives Assessment Protocol* is a decision framework that promotes innovation for safer chemicals. It gives companies a process for identifying alternatives to a chemical of concern, screening out alternatives of equal or greater hazard, and selecting a safer alternative that is technically and economically viable. The Protocol is both descriptive—describes best business practice—and normative—describes how businesses should evaluate and select safer alternatives. Thus it is a recommended decision framework from BizNGO based on business practice.

The Protocol is especially designed for helping to make business decisions, although it may be applicable to government decision making as well. The Protocol highlights the unique role and value of chemical hazard assessment in relation to other approaches for addressing concerns with chemicals in products, including exposure assessment and life cycle assessment. Reducing the inherent hazard of a chemical is an integral principle of Green Chemistry,¹ and this focus on hazard assessment is reflected in the Protocol. The goal is to select a safer alternative than the chemical of concern. Ideally, the safest potential alternative will be selected. However, an alternative may be selected that, while safer than the chemical of concern, may not be the safest among potential alternatives.

Three guidelines, which many companies apply when evaluating and selecting alternatives to chemicals of concern, shape the design of the BizNGO Protocol:

- The decision making lens is from the perspective of downstream users of chemicals evaluating alternatives to chemicals of concern.
- Comparative chemical hazard assessments are essential to identifying a safer alternative—one that is less hazardous to human health or the environment than the chemical of concern.

- Life cycle assessments and risk assessments are not always necessary for selecting a safer alternative—their roles will vary depending on the alternative under consideration.

These guidelines are the foundation for the seven steps of the *BizNGO Chemical Alternatives Assessment Protocol*.

Step 1. Chemicals of concern are the entry point into the alternatives assessment protocol. Government regulations, market demands, and internal company practices are all triggers for identifying chemicals of concern.

Steps 2 and 3. A business needs to know why the chemical is in the material or product to know the universe of potential alternatives. If flame retardancy is the function, then viable alternatives can be identified that range from product redesign—avoid the need for a flame retardant—to material or chemical substitution.

Step 4. Chemical hazard assessments are critical for alternatives assessment because they screen out alternatives that are of equivalent or greater hazard and identify alternatives that are less hazardous than the chemical of concern. After all, companies do not want to make a “regrettable substitution,” such as investing in an alternative that in a few years’ time becomes the object of a new government regulation or decreased market demand. Similarly, hazard assessments precede technical and economic assessments because businesses do not want to invest in evaluating alternatives that may pose problems in the future.

Step 5. With the list of alternatives reduced by the hazard assessment screening, businesses can then evaluate the technical and economic performance of the alternatives. Not surprisingly, technical and economic assessments precede the application of any further environmental or human health assessments because companies do not want to expend scarce resources on alternatives that are not viable from a business perspective.

Step 6. At this point it is time to apply life cycle thinking if the remaining alternatives involve making material or process changes that can result in significant upstream or downstream impacts to the environment or human health. As companies are increasingly concerned with increased carbon footprint, end-of-life management challenges, and worker exposure issues, life cycle evaluations or exposure assessments may need to be conducted at this

point in the evaluation process. Such assessments can be used to further screen out alternatives or to develop mitigation measures for the alternative to reduce its potential for causing significant impacts.

Step 7. Now the company is left with one or a few alternatives to select from that meet technical, economic, environmental, and human health specifications. Because chemical hazard assessments precede life cycle considerations, the Protocol's design ensures that alternatives do not trade increased toxicity for lower carbon footprint or other improved environmental attributes. If greenhouse gas emissions remain a concern, modifications to the production process could be made to reduce the potential carbon impacts of an alternative.

The steps depicted in Figure 1 form a screening logic to selecting and implementing safer alternatives from a list of potential alternatives to the chemical of concern. The Protocol builds upon the rich work of research and development in the field of substitution and alternatives assessment including the Lowell Center for Sustainable Production's Alternatives Assessment Framework;² U.S. Environmental Protection Agency (EPA) Design for the Environment (DfE) Program's approach to chemical alternatives assessment;³

United Nations Environment Programme, Stockholm Convention on Persistent Organic Pollutants, Persistent Organic Pollutants Review Committee's guidance document on substitution and alternatives;⁴ Massachusetts Toxics Use Reduction Institute's *Five Chemicals Alternatives Assessment Study*;⁵ Interstate Chemicals Clearinghouse's Safer Alternatives Assessment Wiki;⁶ and Ökopol and Kooperationsstelle Hamburg's substitution report for the European Union.⁷

The unique lens that BizNGO brings to the field of chemical alternatives assessment is the perspective of what works in business practice, especially for those businesses that use chemicals by virtue of the products they purchase, that is, the "downstream users" of chemicals. These companies are not invested in any particular chemical. They are invested in the function that the chemicals provide and product performance. Thus, their interest is how to identify safer, effective and efficient alternatives to chemicals of concern, as quickly and economically as possible.

Chemicals of concern are the entry point into the alternatives assessment protocol. Government regulations, market demands, and internal company practices are all triggers for identifying chemicals of concern.

Step 1. Identify Chemical(s) of Concern

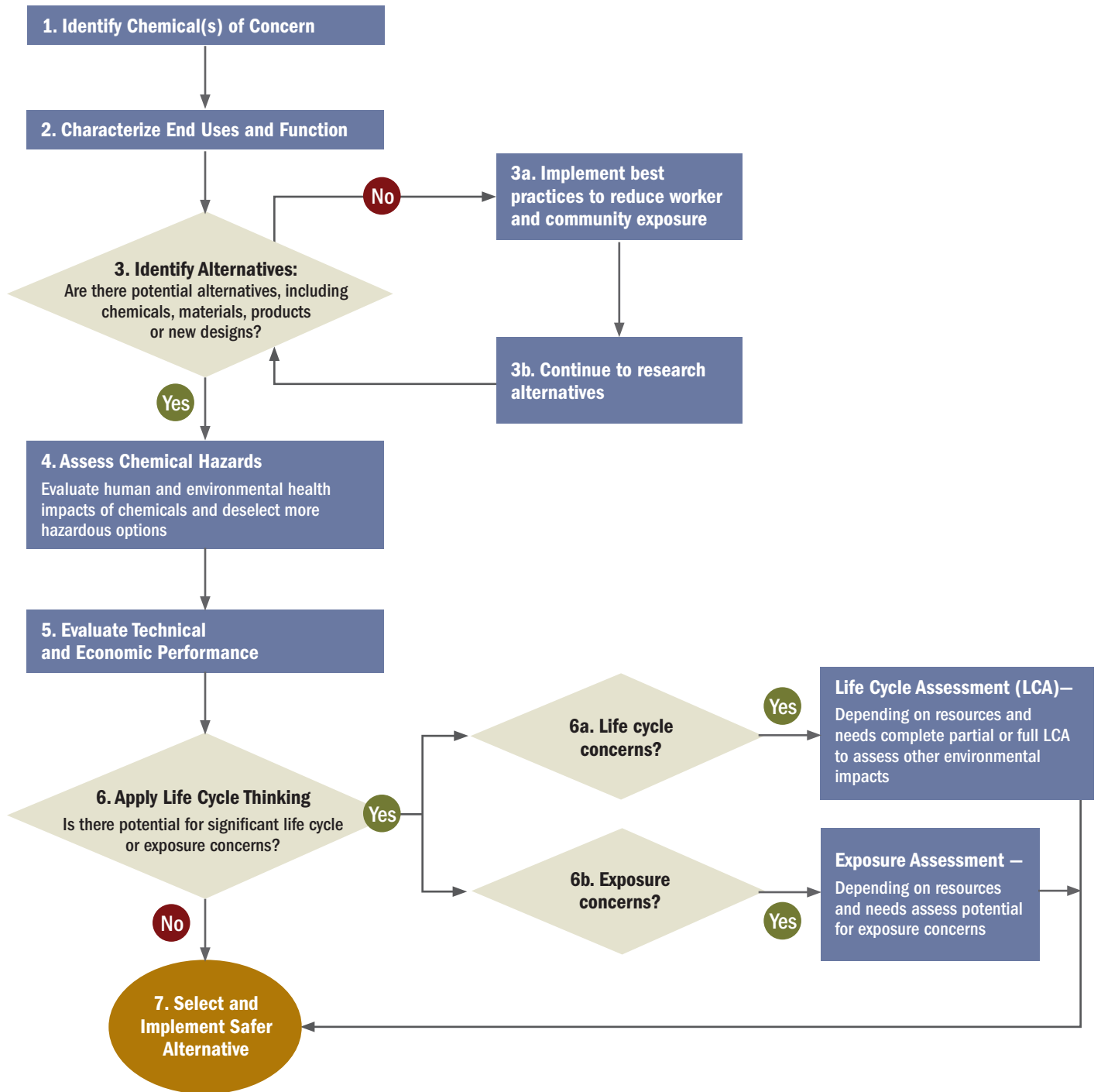
For some companies, the reasons for addressing chemicals of concern change with time and experience. The clothing retailer H&M first began to restrict chemicals in its clothing in 1993, when it decided to restrict the use of toxic Azo dyes in response to German legislation to ban their use. Efforts to look beyond regulatory limits accelerated with the advent of an eco-cotton trend that spread across Europe in the mid-1990s. To meet the new eco-cotton requirements, the company developed its first detailed criteria around acceptable dyeing and finishing chemistry. The eco-cotton trend faded, but it had raised awareness at H&M about the hazards of chemicals used in textile manufacturing. The company decided to adopt the strictest policy of any of the countries in which it operated and later adopted the Precautionary Principle. H&M now updates its restricted substances list (RSL) every few years to add new chemicals or lower allowable limits of selected chemicals already on the list.⁸

The total number of chemicals of high concern a company will track varies from small to large depending on the company, its products, relevant regulations, market

demands, and the criteria used to identify the chemicals. For example, in its report "An Analysis of Corporate Restricted Substance Lists (RSLs) and their Implications for Green Chemistry and Design for Environment," the Lowell Center for Sustainable Production documented hundreds of chemicals that are tracked in corporate RSLs: the lists of chemicals that companies restrict in their own production processes and products and in their supply chains.⁹

Increasingly many end user companies are basing their RSL on existing government or NGO lists. These lists can range from: a handful of chemicals, such as contained in the European Union's Directive on the Restriction of Hazardous Substances in Electrical and Electronic Equipment (RoHS)¹⁰ and the REACH Candidate List of Substances of Very High Concern;¹¹ to the tens of chemicals on Washington State Department of Ecology's Reporting List of Chemicals of High Concern to Children;¹² to the hundreds of chemicals on California's Proposition 65 list of chemicals;¹³ and ChemSec's SIN List.¹⁴ For example, in the health care sector five Group Purchasing Organizations (GPOs), which represent over \$135 billion in contracting

FIGURE 1
 BizNGO Chemical Alternatives Assessment Protocol (v.1.1.1):
Screening Logic for Selecting Safer Alternatives to Chemicals of Concern to Human Health or the Environment*



* The decision logic builds from E. Lavoie, et al., “Chemical Alternatives Assessment,” *ES&T*, 2010, 44(24): 9244-9; and M. Rossi, et al., *Alternatives Assessment Framework*, Lowell Center for Sustainable Production, 2006.

power,¹⁵ are now asking suppliers if their product contains carcinogens or reproductive toxicants listed on California's Proposition 65 list.¹⁶

From their RSLs, companies will prioritize for action a chemical, class of chemicals, or functional class of chemicals. For example, a priority chemical for elimination is

decabromodiphenyl ether (decaBDE); a priority chemical class for elimination is chlorinated and brominated flame retardants; and a priority functional class for identifying safer alternatives is flame retardants. The identification of one of these chemicals, classes, or functions associated with a company's RSL will trigger an alternatives assessment process within the company.

Step 2. Characterize End Uses and Function and Step 3. Identify Alternatives

With the chemical(s) of concern identified, the next steps are characterizing chemical end uses and function and identifying alternatives. Identifying where chemicals of concern are used in manufacturing processes and products is a challenging task. Complex supply chains, confidential business information, and failure to disclose chemical specific data along the supply chain all create barriers to knowing which chemicals are in products.

Companies take many routes to determining which manufacturing processes and products contain chemicals of concern, including: material safety data sheets (MSDSs), Safety Data Sheets (SDSs), third party sources, supplier reporting requirements, and product testing. The more companies know about specific chemicals in their manufacturing processes and products, as opposed to the brand names of chemical formulations and data provided in MSDSs, the less time they spend trying to ascertain the use of chemicals of concern in their supply chain. For a guide on how companies are tracking chemical data across their supply chains and the shortcomings in MSDSs and SDSs, see the Green Chemistry and Commerce Council's report, *Meeting Customers' Needs for Chemical Data*.¹⁷

Knowing which materials and products contain a chemical of concern is a start towards creating a solution. Characterizing the function of a chemical of concern in a product is essential to identifying alternatives. Functionality defines the purpose of the chemical in the product, and thereby frames relevant and viable alternatives.

For example, if flame retardancy (inhibiting or resisting the spread of fire) is the function of the chemical of concern, then viable alternatives can be identified that include:

- **Chemical substitution**—select an alternative flame retardant chemical or chemical formulation

- **Material substitution**—select an alternative material that is inherently flame resistant, thereby meeting flame retardancy needs without the use of a chemical flame retardant. In textile applications, wool is an example of an alternative material that is flame resistant.
- **Product redesign**—change design to eliminate the need for the function, such as remove the source of the fire load (foam padding in a chair, for example) or separate the fire load from the heat source using a barrier technology.
- **System change**—in addition to changing the chemical, material, or product design, change the system for evaluating and assigning flammability standards—from flame test protocols to voluntary standards to government-mandated standards (such as California standard TB 117)¹⁸—to protect the public from both fires and toxic flame retardants.

The goal of a chemical alternatives assessment is to identify a *functionally equivalent and safer alternative*. A functionally equivalent alternative meets the performance needs of a product and includes eliminating the need for the function of a chemical (which is a very effective means to a safer alternative). An assessment of functionality focuses attention on the purpose of the chemical of concern in a product, drives the evaluation of alternatives, and enables the evaluation and ranking of alternatives based on a common unit of measurement. For example, flame retardant alternatives would be assessed against multiple attributes including performance, cost, health, and environment. Functionality is a core element of the U.S. EPA DfE's chemical alternatives assessment approach where "functional use" characterizes the purpose of the chemical and simplifies assessment.³

Manufacturers will primarily turn to their suppliers for alternatives who in turn will identify alternatives based on

their products. Chemical manufacturers and suppliers will identify chemical substitutes, material manufacturers will identify alternative materials, and product designers new design concepts. Additional public resources on alternatives and alternatives assessment include the U.S. EPA's DfE program; Washington State Department of Ecology; Maine Department of Environmental Protection; California Department of Toxic Substances Control; Massachusetts Toxics Use Reduction Institute; Green Chemistry and Commerce Council; Interstate Chemicals Clearinghouse; and SUBSPORT.¹⁹

At the end of Step 3, the manufacturer or relevant entity has identified a set of alternatives. While the alternatives at this stage have not been specifically evaluated for

technical performance, some technical criteria may appear in the list of alternatives. For example, if the alternative flame retardant solution must meet UL 94 V-0 (a stringent flammability standard), then this criterion is likely to be a priority consideration when assessing substitute chemicals and materials for further evaluation. This level of pre-screening for technical performance has its pros and cons. On the plus side, if many alternatives are available it eliminates those that do not meet the more stringent standard. On the negative side, it may remove alternatives that are much more preferable for human health and the environment and which may be able to meet higher standards with incremental improvements. Thus, it is preferable to assess an alternative's technical considerations in Step 5 of the Protocol.

Step 3a. Reduce Exposure and Step 3b. Continue to Research Alternatives

If no potential alternative is identified in Step 3, then the company should implement best practices to reduce worker and community exposure. Companies should follow the industrial hygiene hierarchy of controls: 1) engineering controls; 2) work practice controls; 3) administrative controls; and lastly, 4) personal protective equipment. Extensive resources exist on best practices in occupational safety and health and a discussion of them is beyond the scope of this paper.

The lack of alternatives should catalyze either a company's investment in the development of an alternative or support from manufacturers, universities, and governments to develop safer alternatives. The manufacturing marketplace is dynamic with frequent innovations in chemicals, materials, products, and systems. Even if an alternative is not immediately available, companies should actively continue to look for one.

Step 4. Assess Chemical Hazards

Hazard assessments are necessary for chemical alternatives assessment because they screen out alternatives that are of equivalent or greater hazard and identify alternatives that are less hazardous than the chemical of concern. After all, companies do not want to make a "regrettable substitution," such as investing in an alternative that in a few years' time becomes the object of a new government regulation or decreased market demand. Similarly, hazard assessments precede technical and economic assessments because businesses do not want to invest in evaluating alternatives that may pose problems in the future.

The *BizNGO Chemical Alternatives Assessment Protocol* separates hazard assessment (Step 4) and exposure assessment (Step 6b) into two separate steps. This is consistent with risk assessment, where risk is a function of hazard times exposure. The BizNGO Protocol differs

from risk assessment in that it does not require exposure assessments prior to selecting an alternative. The need for exposure assessments before selecting an alternative will vary with each selection.

Hazard data alone are sometimes sufficient for selecting a safer alternative for a range of reasons including:

- The most effective means for reducing exposure, and thereby risk, is to eliminate the hazard. Reducing hazard is at the foundation of the 12 Principles of Green Chemistry¹ and the Pollution Prevention Act of 1990.²⁰
- Hazard assessments are especially useful in the design phase before details relevant to exposure assessments are known, including how the product will be manufactured, used, and disposed.

- Relative to other life cycle impacts, the inherent hazard of a chemical cannot be changed. Opportunities nearly always exist to reduce the impacts of a product on endpoints like water and air pollution through increased efficiencies in manufacturing, use, maintenance, end-of-life management, and transportation. But the hazards of a chemical are fixed and only exposure can be reduced.

Comparative chemical hazard assessment is a method for evaluating and comparing the inherent hazards of a chemical and identifying environmentally preferable alternatives. Examples of comparative chemical hazard assessments include the U.S. EPA DfE report on alternatives to pentabromodiphenyl ether (pentaBDE) in low density polyurethane foam.²¹ This report evaluates and compares chemicals based on hazards but does not identify preferred alternatives. Another chemical hazard assessment tool is Clean Production Action's GreenScreen® for Safer Chemicals, which evaluates and compares chemicals based on hazards and identifies preferred alternatives.²²

The final result of a GreenScreen® assessment is to benchmark a chemical into one of the following four bins:

- **Benchmark 1:** "Avoid—Chemical of High Concern"
- **Benchmark 2:** "Use but Search for Safer Substitutes"
- **Benchmark 3:** "Use but Still Opportunity for Improvement"
- **Benchmark 4:** "Prefer—Safer Chemical"

Benchmarking a chemical using the GreenScreen® involves:

a) assessing and classifying a chemical's hazards and
b) applying the results to the GreenScreen® benchmark criteria. To assess and classify a chemical, hazard data for 18 endpoints are collected indicating the type of data used. Then each endpoint is categorized into one of four levels of concern to human health and the environment (very high, high, moderate, or low). Types of data used to assign this categorization range from results of experimental tests to modeling assessments, such as quantitative structure activity relationships (QSARs), to expert assessment. The GreenScreen® classification system aligns with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) and with the U.S. EPA DfE program's chemical alternatives assessment approach.³

Once each endpoint for a chemical is classified to its level of concern, the next step is to benchmark the chemical in terms of its overall performance in relation to human and environmental health. The GreenScreen® uses an algorithm

to combine the levels of concern for each of the 18 endpoints into one single benchmark ranging from Benchmark 1 (chemical of high concern) to Benchmark 4 (safer chemical). Note that the GreenScreen® includes a chemical's breakdown products in its hazard assessment because these may be more hazardous than the parent compound. The final benchmark for a parent chemical is the lowest benchmark achieved by either it or its breakdown products.²³

The intent of a comparative chemical hazard assessment is to guide decision making toward the use of less hazardous options via a process of informed substitution. "Informed substitution" is the considered transition from a chemical of particular concern to a safer chemical or nonchemical alternative.²⁴ Informed substitution builds on the best available information and leads to cleaner production and the development or use of less hazardous chemical and non-chemical technologies. It also helps to minimize the opportunity for unintended consequences.

In Step 4 of the Protocol, chemical alternatives whose chemical hazard benchmark is equal to or worse than the chemical of concern are deselected from consideration as a safer alternative. If the chemical and its breakdown products are a GreenScreen® Benchmark 1 (like decaBDE) then the alternatives must be a GreenScreen® Benchmark 2 or higher to continue in the alternative assessment process. An alternative that removes the need for the chemical function entirely, would be considered the equivalent of a GreenScreen® Benchmark 4.

Government agencies and research institutions are developing quick screen assessment tools and approaches for pre-screening the hazards of chemicals, including the Washington State Department of Ecology's Quick Chemical Assessment Tool (QCAT) and the Massachusetts Toxics Use Reduction Institute's (TURI) *Five Chemicals Alternatives Assessment Study*. TURI in its approach, for example, pre-screened its list of alternatives before moving on to more in-depth assessments of technical performance, cost, and other life cycle concerns. TURI screened out alternatives that are: known or probable carcinogens; determined to be persistent, bioaccumulative and toxic (PBT); or listed as a More Hazardous Chemical by the Toxics Use Reduction Act, Science Advisory Board.⁵

If Step 4 screens out all alternatives as being of greater or equal hazard than the chemical of concern, then the protocol takes the user back to Steps 3a and 3b.

Step 5. Evaluate Technical and Economic Performance

With the list of alternatives narrowed by the Step 4 hazard assessment screening, technical and economic performance can now be evaluated. Not surprisingly, technical and economic assessments precede the application of any further environmental or human health assessments because companies do not want to expend scarce resources on alternatives that are not viable from a business perspective.

Assessing the technical and economic performance of alternatives can be challenging. Ideally technically viable alternatives meet the same performance specifications as the product with the existing chemical of concern. But the level of performance in existing products may be higher than necessary. For example, product designers may decide to meet a higher flammability standard just to ensure the product is ahead of any future and more stringent flammability standards or regulations. Meeting the higher standard may result in the elimination of safer alternatives that are “functionally equivalent” and sufficient for meeting the performance needs of the product.

Estimating the cost of alternatives is similarly nuanced. The direct purchase price of an alternative does not reflect the total cost of that alternative over the life of the product, including use, maintenance, and end of life management, nor is price fixed. Increased demand for an alternative will lower cost over time as manufacturers achieve economies of scale. Frequently technically equivalent alternatives are available to existing chemicals of concern, but they may involve economic trade-offs such as low production volumes and high cost or accepting performance that is not best in class but is sufficient for the product. For an in-depth examination of financial evaluations in alternatives assessments, see TURI’s *Five Chemicals Alternatives Assessment Study*.⁵

Step 5 may eliminate alternatives that made it through the hazard assessment in Step 4. The remaining alternatives continue on to Step 6. And if no alternatives make it through Step 5, then the protocol takes the user back to Steps 3a and 3b.

Step 6. Apply Life Cycle Thinking

Life cycle thinking is the process of evaluating the potential impacts to human health or the environment across the life cycle stages of a chemical, material, or product. The BizNGO Protocol uses life cycle thinking to review the remaining alternatives at each life cycle stage and identify potentially significant impacts that may result from their adoption. The application of life cycle thinking enables companies to address other human health and environmental impacts of the alternatives, including global warming, end-of-life management challenges, and worker exposure by screening out some alternatives and developing mitigation measures as needed. Note that the Protocol includes exposure assessment in life cycle thinking but then separates exposure assessment from life cycle assessment to clarify that these are two different disciplines with well-defined methods of analysis.

For chemical substitutes with the same functional use and a similar life cycle as the initial chemical of concern identified in Step 1, further assessments may not be necessary and Step 6 can be skipped. In the U.S. EPA DfE’s chemical alternatives assessment approach, Lavoie, et al., note that “Where similar product and chemical use patterns are

expected, exposure can be considered a constant. As a result, risk (defined as hazard multiplied by exposure) can be reduced through a reduction in chemical hazard.”³ In this scenario, exposure assessments are not needed for the alternative chemical because, all other factors equal, exposure to the alternative will be similar to exposure to the initial chemical of concern; with reduced hazard (as determined in Step 4), the chemical substitute becomes the safer alternative (Step 7).

For alternatives that involve material, process, and product changes, evaluations of life cycle impacts and exposure assessments may be appropriate depending on how much the alternative differs from current practices. Evaluations of life cycle impacts vary widely in terms of type and scope. They range from the consideration of specific endpoint impacts such as greenhouse gas generation to qualitative assessments (performed along the lines of the TURI *Five Chemicals Alternatives Assessment Study*⁵) to full quantitative life cycle assessments (LCAs) using commonly available tools.²⁵ LCAs will help to identify significant life cycle impacts of the alternatives and possible mitigation measures, as well as to differentiate the remaining alternatives.

If alternatives do not have the same functional use and a similar life cycle as the initial chemical of concern, then exposure assessments of the alternatives will help to flag concerns—during manufacture, installation, use, maintenance, and end of life management. Some companies may choose to conduct an exposure assessment and complete a full risk assessment in this situation. It is beyond the scope of the BizNGO Protocol to delve into the details of exposure assessments and LCA methods or to recommend specific approaches. What is important in Step 6 is that businesses consider other life cycle impacts of alternatives, identify significant impacts and measures to mitigate these impacts, and use the results of these assessments to differentiate among the remaining alternatives.

Comprehensive risk assessments and formal life cycle assessments are very expensive, time consuming to prepare, and often involve significant data gaps. Therefore most companies choose to use readily available data to perform

qualitative exposure and/or life cycle evaluations. The TURI *Five Chemicals Alternatives Assessment Study* provides a good example of how to apply life cycle thinking. In its assessments of alternatives to DEHP, perchloroethylene, lead, hexavalent chromium, and formaldehyde, TURI considered and evaluated potential concerns for each life cycle stage (as well as human exposure concerns). The depth of assessment varied depending on the chemical of concern, its use and function, and the alternatives under consideration.

At the completion of Step 6, businesses will have a comprehensive picture of an alternative's cost, performance characteristics, and its human health and environmental impact concerns.

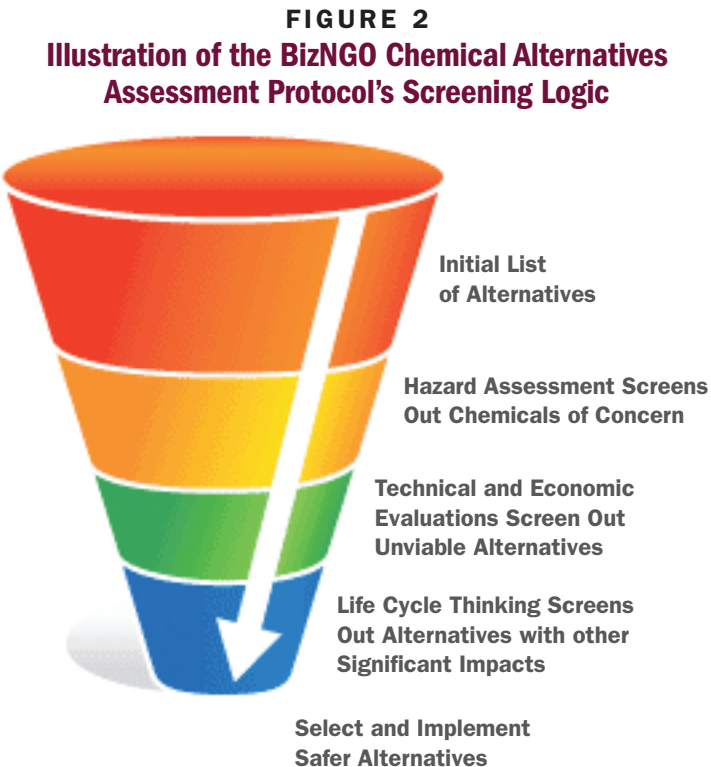
In Step 7 the company selects and implements the alternative that best meet its needs. This is one step in a firm's ongoing commitment to innovative and safer alternatives.

Step 7. Select and Implement Safer Alternative

Now the company is left with one or a few alternatives to select from that meet its economic, environmental, and human health criteria. The Chemical Alternatives Assessment Protocol provides a framework to help companies with this commitment. By using chemical hazard assessment as a first screening tool, companies can relatively quickly identify and eliminate more hazardous potential alternatives from further consideration.

Because chemical hazard assessments precede life cycle considerations, the Protocol's design ensures that alternatives do not trade increased toxicity for lower carbon footprint or other improved environmental attributes. If greenhouse gas emissions remain a concern, modifications to the production process could be made to reduce the potential carbon impacts of an alternative. Figure 2 illustrates how the Protocol's screening logic pares down alternatives to the most viable safer alternative.

The Chemical Alternatives Assessment Protocol is informed by the experience of businesses that do this work every day, including Hewlett-Packard (HP), Shaw, and Construction Specialties. It builds on methods developed by leaders in the field, notably the Lowell Center for Sustainable Production, Toxics Use Reduction Institute, and the U.S. EPA's DfE Program. This is version 1.1 of the Protocol and we anticipate that it will evolve over time to reflect increased experience and understanding in implementing chemical alternatives assessments.



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19. See: SUBSPORT, Substitution Support Portal, at: <http://www.subsport.eu>—accessed November 25, 2011.
20. The primacy of hazard reduction as the preferred option for reducing risk is established in the Pollution Prevention Act of 1990, which defines pollution prevention as any practice that "reduces the hazards to public health and the environment." Public Law 101–508, November 5, 1990, Omnibus Budget Reconciliation Act of 1990 (Pollution Prevention Act of 1990).
21. U.S. Environmental Protection Agency, Design for the Environment, *Environmental Profiles of Chemical Flame-Retardant Alternatives for Low-Density Polyurethane Foam* (2005, <http://www.epa.gov/dfe/pubs/flameret/ffr-alt.htm>—accessed April 8, 2011).
22. M. Rossi and L. Heine, *Green Screen for Safer Chemicals: Evaluating Flame Retardants for TV Enclosures*, (2007, http://www.bizngo.org/static/ee_images/uploads/resources/EvaluatingFlameRetardantsGreenScreenSaferChemicals_2007.pdf).
23. For further details on the GreenScreen™ see: <http://www.cleanproduction.org/Greenscreen.php>—accessed November 28, 2011.
24. U.S. Environmental Protection Agency, *Design for the Environment Safer Product Recognition Program Elements: A Discriminating and Protective Approach to Product Review and Recognition* (2009, http://www.epa.gov/dfe/pubs/formulat/formulator_review1.pdf—accessed May 4, 2011).
25. Life cycle assessment (LCA), according to the U.S. EPA, "is a 'cradle-to-grave' approach for assessing industrial systems. 'Cradle-to-grave' begins with the gathering of raw materials from the earth to create the product and ends at the point when all materials are returned to the earth. LCA evaluates all stages of a product's life from the perspective that they are interdependent, meaning that one operation leads to the next. LCA enables the estimation of the cumulative environmental impacts resulting from all stages in the product life cycle, often including impacts not considered in more traditional analyses (e.g., raw material extraction, material transportation, ultimate product disposal, etc.). By including the impacts throughout the product life cycle, LCA provides a comprehensive view of the environmental aspects of the product or process and a more accurate picture of the true environmental trade-offs in product and process selection." Source: U.S. Environmental Protection Agency, National Risk Management Research Laboratory, Office of Research and Development, *Life Cycle Assessment: Principles and Practice* (2006, <http://www.epa.gov/nrmrl/lcaccess/lca101.html>—accessed April 8, 2011): page 1.



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