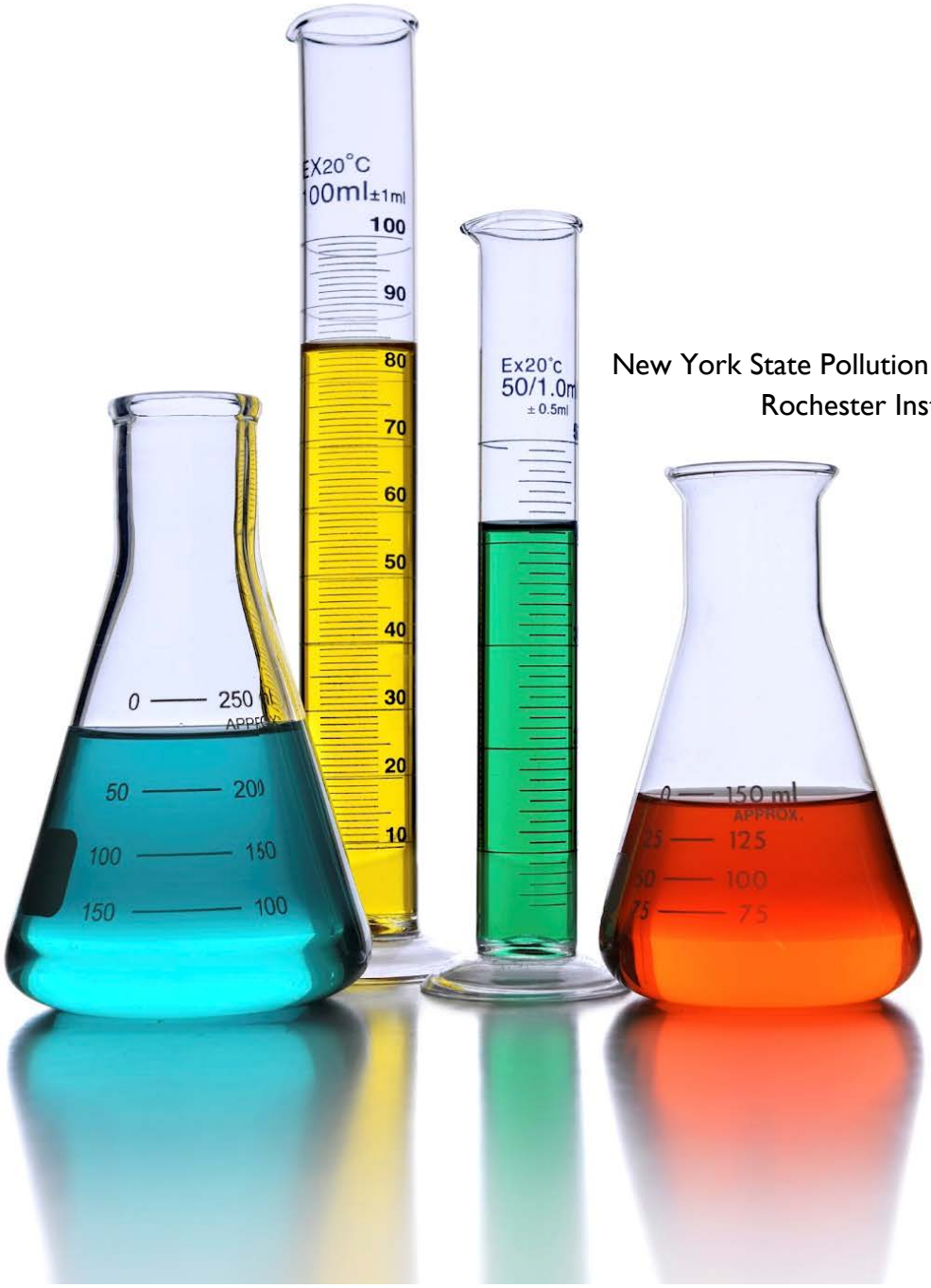
Decision Making in Alternatives Assessment

New York State Pollution Prevention Institute

Case Studies



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Acknowledgements

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Executive Summary

This document summarizes the results of the New York State Pollution Prevention Institute's (NYSP2I) review of the Interstate Chemicals Clearinghouse's (IC2) Alternatives Assessment Guide (the Guide). In an effort to identify any gaps in the Guide, NYSP2I reviewed three companies that have implemented alternative chemicals or are in the process of identifying and assessing alternatives. In this report, NYSP2I summarizes the three case study companies' alternatives assessment (AA) processes and compares them to the process outlined in the Guide. Gaps in the Guide are noted along with potential measures that may be taken to address the gaps identified. Models for displaying AA information and results, to facilitate decision-making at the company level, are also included in this report.

Case Study Findings

The three case study companies include: (1) a dry cleaner that converted from perchloroethylene to professional wet cleaning, (2) a plastic products manufacturer that is seeking a flame retardant, and (3) a chemical company that sought an alternative for methyl ethyl keytone (MEK).

The AA processes used at the case study companies were compared to the process outlined in the Guide. Highlights of the results are below and a summary of the companies' use of the modules is provided in Table 1.

- One company followed the Sequential Framework presented in the Guide. The other two companies had well thought out and executed AAs, but they did not easily fit into one of the Guide's three frameworks.
- The companies did not include all four of the required modules (Hazard, Performance, Cost & Availability, Exposure Assessment) in their AAs.
- Of the modules they did include, the companies did not perform thorough analyses for each Module in their assessment.
- Upon reviewing the case studies in this report, there did not appear to be attributes considered by the companies that were not included in the AA Guide.

Table 1: Case study companies' use of IC2 AA Guide modules

	Dry Cleaner	Plastic Products Manufacturer	Chemical Company
Stakeholder Involvement Module	None	none	none
Frameworks Module	Simultaneous	did not follow	did not follow
Required Modules			
Hazard Module	Initial Screen	Initial Screen	Initial Screen
Performance Evaluation Module	Level 2	mix of Level 2 & 3	mix of Level 2 & 3
Cost and Availability Module	Level 2	mix of Level 3 & 4	mix of Level 3 & 4
Exposure Assessment Module	Initial Screen	Initial Screen	none
Optional Modules			
Materials Management Module	Level 1	Level 2	Level 1
Social Impact Module	Level 1	Level 3	none
Life Cycle Module	None	none	none

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Significant Recommendations

A number of recommendations are made throughout this report. The three recommendations below are those which the NYSP2I believes to be of most value to users of the AA Guide at this time.

1. **Goal and scope guidance.** It is recommended that a guidance document be created that explains the process and considerations when crafting the goal and scope of an AA. Examples of well thought out and poor goals and scopes should also be included to give practitioners practical examples.
2. **Streamlined AA process for SMEs.** It is recommended that a streamlined AA process be developed to meet the needs of smaller companies. This streamlined AA would be an abbreviated version of the Guide that uses the current AA Guide as a reference, consequently encouraging, rather than discouraging, the use of a systematic approach for AA. As the case study companies included in this report show, small and medium sized companies (SME) are performing AAs, typically without the use of a structured format. A streamlined AA would provide a simple framework for companies to perform an AA, ensuring that relevant attributes are included in the AA.

   It is also recommended that a "cheat sheet" or table that clearly outlines the impacts is included within each Module of the Guide. This cheat sheet may be a short document that allows a practitioner to quickly determine under which Module an impact falls and provide a reference to ensure all relevant impacts are included in the AA.

3. **Guidance to display results.** Multiple methods to display AA Guide results were developed and are presented in this report. All methods assume that the goal and scope of the AA have been well defined upfront.

   a. **Develop a set of "yes/no" or "pass/fail" criteria** for each of the modules to be included in the analysis, and perform the AA for the chemical of concern as well as the alternatives. This allows the user to quickly see which alternatives meet the criteria within each module. It is important to note that this method does not account for the level at which an alternative meets the criteria. *This method may best be suited for a preliminary screen of alternatives*.
   b. **Determine criteria for each of the modules and evaluate them relative to the alternative, using a system of +/=/- or >/=/<.** This process is relatively straight forward and will allow the user to quickly identify those alternatives that are better than the chemical of concern, any potential hot spots for further investigation, and areas where a seemingly favorable alternative is not actually favorable. *This method is best suited for a preliminary screen of alternatives.*
   c. **Develop a set of high/moderate/low criteria** for each of the modules to be included in the analysis, and perform the AA for the chemical of concern as well as the alternatives. This process is used by the EPA Design for Environment Program to perform the hazard evaluation portion of the AA and criteria can be found in "Design for the Environment Program Alternatives Assessment Criteria for Hazard Evaluation". This process takes considerable time to set up the criteria as well as perform the analysis. *Thus, this method may best be suited for assessing remaining alternatives that pass a preliminary screening.*

4. **Methods to facilitate decision making.** While the Guide mentions methods used to address complex decisions, the methods are described somewhat vaguely and do not describe *how* to implement them and actually make decisions. Value judgements are inherently a part of this process, so transparency and documentation of the weighting and judgements used is critical. Adjusting the weighting factors could therefore change the outcome of the assessment.

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5. **Determine high/moderate/low priority criteria and screen out alternatives based on high priority criteria**, then moderate, and finally low priority criteria. This is similar to the process that the GreenScreen® for Safer Chemicals uses with their Benchmarks™ when assessing the hazard associated with chemicals.
6. **Determine high/moderate/low priority criteria and assign numerical values to them** (such as 1, 2, 3). The values are added to rank the alternatives.

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1. Project Goals & Methodology

The Interstate Chemicals Clearinghouse (IC2) and participating states released the IC2 Alternatives Assessment Guide (the Guide) in January 2014. The New York State Pollution Prevention Institute (NYSP2I) is supporting the development of the Guide by reviewing three companies that have implemented alternative chemicals or are in the process of identifying and assessing alternatives in order to identify factors such as cost, feasibility, etc., that are critical for companies to use to make a decision. Based on the findings of this review, in this report, NYSP2I proposes models for displaying the alternatives assessment (AA) information and results to better facilitate decision-making at the company level. There is also strong interest among IC2 members in folding into that work an emphasis on presenting a fully comprehensive set of data that includes hazard, cost and feasibility—the full array of information that companies need to make a decision and take action.

NYSP2I has expertise and experience working with companies to assess, evaluate, and implement alternative chemicals, products, or processes. For this project, NYSP2I studied the efforts of three past NYSP2I clients which have implemented a chemical alternative, collecting data related to this process. The goal was to better understand (1) the information companies use to make a decision and take action and (2) the financial impact of substitution.

Case studies

Materials from the NYSP2I projects with the three subject clients, including project reports and case studies, were reviewed. Discussions with NYSP2I project staff and correspondence with company personnel were held to better understand the AA process utilized.

Through this effort, NYSP2I sought to understand:

- The reasons a company sought an alternative
- Current status of the project/process
- Factors included in evaluating alternatives, including those that were most and least important
- Tools companies used to find and evaluate alternatives, if any, such as GreenScreen, the Guide, etc.
- Total costs—both real and avoided—to implement an alternative, including materials, equipment, processing, infrastructure, training, safety equipment, etc., and
- Additional unexpected costs and benefits of the alternative, both tangible and intangible.

The results of this analysis follow in this report. The AAs were also used to propose methods to display the AA Guide results in order for a company to better interpret them and to facilitate company decision making.

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2. Case Studies

A. Dry Cleaner Converts to Professional Wet Cleaning

After using perchloroethylene (perc) for 15 years, a NYS dry cleaner became increasingly concerned about the environmental and health impacts of perc and was interested in finding an alternative; however, he had no previous experience with alternative dry cleaning solvents. Through word of mouth, the cleaner became interested in professional wet cleaning as an option. Consequently, the owner visited many successful wet cleaners and attended the CleanShow (the largest US dry cleaning tradeshow) to learn more about the benefits and practicality of wet cleaning. NYSP2I also helped connect the cleaner to wet cleaning equipment vendors to learn more. The dry cleaner evaluated other alternative dry cleaning technologies, including new perc and hydrocarbon systems, ultimately choosing wet cleaning. Working with the equipment vendor, the cleaner determined the appropriate system to meet his needs, determined when to install the professional wet cleaning machine and determined when to remove the perc dry cleaning machine. In September of 2011, the dry cleaner converted his operation to dedicated professional wet cleaning, and in December 2011 the cleaner removed his perc machine.

Reasons an alternative was sought

The cleaner was interested in an alternative cleaning system due to the potential health and environmental impacts of perc dry cleaning. The cleaner was interested in the promise that professional wet cleaning is healthier for employees, has minimal environmental impact and can clean garments as well as or better than perc.

Methods used to identify alternatives

The cleaner needed to invest in new garment cleaning equipment. Although he was explicitly interested in professional wet cleaning, he wanted to explore all options before making a final decision. He visited a garment cleaner's facility in Toronto to observe a professional wet cleaning operation first hand. Afterward, he was 100% confident in the viability of converting his facility to professional wet cleaning. The following month, he attended the 2011 Clean Show in Las Vegas to observe a wide range of garment cleaning technologies. About one month later, he visited a professional wet cleaner in Brooklyn to further affirm his decision. Having investigated professional wet cleaning for a few months, the cleaner decided to proceed with replacing his perc dry cleaning machine with a professional wet cleaning system.

Factors involved in evaluating alternatives

Neither tools nor a structured evaluation of alternatives were used by the cleaner.

The most important factors to the cleaner were, in order of importance:

1. Health impact: alternative must have no or low health impacts, as employees were complaining of headaches and dizziness with perc dry cleaning
2. Performance: alternative had to perform as well as or better than dry cleaning and could not require more time or resources than perc dry cleaning
3. Cost: the cleaner was willing to spend slightly more for alternative equipment and operating costs

Total costs and benefits (real & avoided) of implementing the alternative

The cleaner's professional wet cleaning system, including washer, dryer, and tensioning machines, cost was approximately $50,000. The cleaner did not spend more for the system compared to a perc system, as a new perc cleaning system can range in cost from $40,000-$65,000.

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Since converting to wet cleaning, the cleaner reported quality has increased, as shown by more than a 99.9% reduction in send-outs, re-dos, and claims. The operation's electricity usage has decreased by one third and natural gas usage has also decreased. The cleaner is saving money by using the alternative, and perc use and its associated health and environmental effects as well as hazardous waste are eliminated. The cleaner reports employees are happier operating in a cleaner environment, without the smell of perc and his customers are pleased with the quality of cleaned garments.

Metrics	2012 Estimated Annual Savings	2013 Estimated Annual Savings
Performance	99.98% reduction in quality defects	99.96% reduction in quality defects
Electricity usage	34% reduction	33% reduction
Natural gas usage	1.6% reduction	30% reduction
Detergent & spotter usage	4% increase	11% reduction
Perc used for cleaning	173 gallons, 100% eliminated	173 gallons, 100% eliminated
Filters & equipment maintenance	100% eliminated	100% eliminated
Hazardous waste disposal	766 pounds, 100% eliminated	766 pounds, 100% eliminated
Perc air pollution	852 pounds, 100% eliminated	852 pounds, 100% eliminated
NYSDEC permit	permit eliminated	permit eliminated
Total	**$28,000+ reduction in costs**	**$31,000+ reduction in costs**

Table 2: Comparing Jan- Dec 2010, Jan-Dec 2012, and Jan-Dec 2013 operating data. Data are normalized to pieces cleaned in 2012.

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B. Plastic Products Manufacturer seeks Flame Retardant

Polyvinyl chloride (PVC) based flue duct materials are currently used widely in heating exhaust system applications, including high efficiency air (furnaces) and hydronic boilers and water heating equipment. A plastic product manufacturer in NYS has developed a polypropylene-based alternative flue duct material. While this product is currently widely used and accepted in Europe, and it meets or exceeds the application requirements for heat ducting as identified by UL standards, the product does not contain an added flame retardant, which the UL standards require.

Flame retardant chemicals currently available on the market have negative environmental and/or human health attributes which are undesirable to the company. Therefore, the company is searching for a material for their product to meet the UL listing requirements with minimal impact. Simultaneously, the company is meeting with UL staff to determine if there are methods other than adding a chemical flame retardant that would allow the flue duct material to be UL listed. The company is in the process of identifying an alternative.

Reasons an alternative was sought

An alternative flame retardant additive for the flue duct product is being sought that is able to meet the UL listing requirements while having low environmental and health impacts. Current flame retardant additives that meet UL listing requirements have relatively high environmental and health impacts.

Methods to identify alternatives

The company has reached out to current suppliers to identify potential flame retardant additives that are currently used in similar products that may also be used in this application. Simultaneously, the company is performing internet searches to identify alternatives used in similar applications.

Factors involved in evaluating alternatives

Once a potential alternative is identified, its environmental risks (below) will be evaluated as well as potential manufacturing concerns, specifically additional tooling requirements, as many flame retardant additives can significantly impact tooling and machining in the production process.

Environmental risks and manufacturing criteria include:

1. Chemical release
2. Improper installation
3. Worker exposure
4. Temperature excursion
5. Material degradation
6. Chemical leaching
7. House fires
8. Material recycling
9. Material landfill disposal

Alternatives that pass the environmental risk and manufacturing criteria above are then tested internally by the company for performance. Those that pass performance testing will move forward with UL testing.

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C. Chemical Company seeks Alternative for MEK

This NYS chemical company used approximately 13,500 pounds (~2,000 gallons) of 100% methyl ethyl keytone (MEK) per year as a bonding solvent for acrylonitrile butadiene styrene (ABS) plastic components. As a result of a revision to New York State Department of Environmental Conservation (NYSDEC) Regulation Part 228, the company must comply with a volatile organic compound (VOC) limit of 510 grams/liter for "other plastic cement welding" (Table 1 of 6NYCRR Part 228-2.4)[1]. In order to remain in compliance, the facility would need to reduce their use of pure MEK to 55 gallons/year or less.

The company had two options to meet the emissions limit: reduce the amount of MEK used or replace the MEK with a low or no-VOC alternative. The company worked with an environmental firm to create a Reasonably Available Control Technology (RACT) plan to reduce the amount of MEK used in order to meet the VOC emission control limit. The company also requested assistance from NYSP2I to identify potential alternatives to MEK. NYSP2I identified and tested a number of alternatives and ultimately found a blend of acetate and methyl n-propyl ketone (MPK) as an alternative to MEK, which had the potential to meet the VOC limits. The company ultimately chose a RACT plan as an alternative to meet VOC emissions control requirements.

Reasons an alternative was sought

An alternative to MEK was sought in order to meet NYS VOC emission control requirements of less than 510grams/liter as defined in Table 1 of 6NYCRR Part 228-2.4.

Methods to identify alternatives

The company requested assistance from NYSP2I to identify potential alternatives to MEK. Based on common knowledge in the field, NYSP2I experts knew that plastics are most commonly bonded by using ultrasonic welding, adhesives, or solvents. These three methods were reviewed for consideration as alternatives to MEK for bonding ABS plastic.

NYSP2I identified alternatives via internet searches, correspondence with sales representatives, consultation with NYSDEC, benchmarking other adhesive applications that would eliminate the need for MEK altogether, and laboratory trials.

Factors involved in evaluating alternatives

NYSP2I used a structured evaluation to assess the alternatives. Alternatives had to meet the following requirements, per the chemical company, in order to be deemed viable:

1. Must contain < 510 grams VOC per liter to comply with Table 1 of 6NYCRR Part 228-2.3
2. Must have compatibility rating with ABS of "Severe" (not compatible)
3. Must have a bond strength / lap shear similar to MEK of 548 – 602 lbf (or 4384 – 4816 psi) per NYSP2I tensile testing
4. Manufacturing process must be similar to current process of dipping the plastic parts in a well, followed by simple fixturing for assembly to maintain productivity levels
5. Must have a similar evaporation rate as MEK for process throughput considerations
6. Must have a Flash Point higher than that of MEK (16F)
7. Must be similar in cost to MEK

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First, non-chemical bonding alternatives - ultrasonic welding (high frequency vibration), friction welding (spin welding), and vibration welding (linear friction welding) – were researched. These processes were considered first as they eliminate the use of solvents. These methods were not viable as they are cost prohibitive due to the need to acquire new equipment and/or modify existing plastic injection molds.

Second, adhesives – specifically cyanoacrylates and acrylics – were researched as they also eliminate the need for solvents and have very low VOC content. One product was identified that met both the lap shear strength and VOC content limits. Ultimately the adhesive was not deemed a viable option though, due to: the amount of time required to apply the product (significantly more compared to the MEK process), potential for unreliable consistency of application by employees, and a cost more than four and a half times that of MEK.

Lastly, chemical solvents were researched. The key goal was to identify chemicals with properties similar to MEK – degrading ABS to form a softened surface which would create a plastic bond, with the chemical solvent evaporating off the part in the process – that also met the VOC limit of 510g/L. The following process was used to identify alternative solvents:

1. Identified the "*not* volatile organic compounds" defined by "*Volatile organic compound (VOC)"* in 6NYCRR Part 200.1(cg) list of compounds. The list was narrowed by eliminating hazardous air pollutants, such as methylene chloride.
2. The remaining eight solvents were cross referenced with sources listing chemicals that are compatible with ABS plastic.
3. The list was narrowed to two solvents compatible with ABS plastic. NYSP2I and the chemical company discussed the possibility of using the two solvents.
    a. One solvent was not desired due to a low flash point; however, in conversations, it was discovered that a blend of MEK and this alternative solvent may provide a low-VOC alternative with high bonding potential. NYSP2I performed a literature search and determined that this chemical blend may be viable. NYSP2I identified an off-the-shelf product and successfully performed a lap shear test. While the product would cost about half of the cost of MEK, ultimately the chemical company decided not to use this product, as application would be time consuming and quality would be difficult to control.
    b. The other solvent alternative also has a low flash point. Solvent blends were investigated and the physical qualities of the chemical blend and MEK were compared. Due to project scope constraints, NYSP2I was unable to test the blend. NYSP2I suggested that the chemical company move forward with testing independently as a next step, if interested in using the alternative solvent.
4. Seven additional chemicals were evaluated for their use as an alternative. Lap shear and application technique issues narrowed the list of potential alternatives to one.
    a. The one alternative is 100% bio-based, biodegradable, and is not flammable. NYSP2I performed lap shear tests, with varied results. Ultimately, this alternative was not found to be a viable option as it was revealed that the VOC content exceeded the regulatory requirement.
5. The chemical company requested NYSP2I evaluate six additional chemical solvents. The chemicals' VOC content and ability to attack ABS were considered. None of the chemicals were found to be viable options.
6. NYSP2I reached out to their professional networks for alternatives to MEK. Three potential alternatives were identified and their VOC content and the ability to attack ABS were evaluated. None of the alternatives met the requirements.

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Total costs and benefits of implementing the alternative

As part of their RACT, the company chose a method that requires more careful handling by operators to reduce their usage below 55 gallons per year to comply with the NYS VOC limits. The company was concerned that the MEK-chemical blend identified by NYSP2I is not proven and significant time and resources would be required to test the blend, without a guarantee of results.

Moving forward, the chemical company plans to regularly improve their processes and designs to reduce overall MEK consumption since a viable alternative was not identified.

Since the project, changes to new product designs have been a focus on any product where the company would have historically used a solvent bond, in an effort to replace the solvent bond with a physical one, thus removing the need for a chemical solvent.

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3. Case Study Comparison to IC2 AA Guide

The methods used to identify alternatives for each case study company were reviewed against the IC2 AA Guide to identify gaps in the Guide and provide opportunities for improvement based on real-world situations. The AA Guide modules are listed below in Table 3, along with a summary of their use (or similar) by the case study companies. Details for each of the modules follow.

Table 3: Case study companies' use of IC2 AA Guide modules

	Dry Cleaner	Plastic Products Manu.	Chemical Company
Stakeholder Involvement Module	none	none	none
Frameworks Module	Simultaneous	did not follow	did not follow
Required Modules			
Hazard Module	Initial Screen	Initial Screen	Initial Screen
Performance Evaluation Module	Level 2	mix of Level 2 & 3	mix of Level 2 & 3
Cost and Availability Module	Level 2	mix of Level 3 & 4	mix of Level 3 & 4
Exposure Assessment Module	Initial Screen	Initial Screen	none
Optional Modules			
Materials Management Module	Level 1	Level 2	Level 1
Social Impact Module	Level 1	Level 3	none
Life Cycle Module	none	none	none

Stakeholder Involvement Module

This module ensures stakeholders are considered in the AA process. It provides information so concerned parties can understand what decisions are being made, why these specific decisions were made, and can provide input into that process.

None of the case study companies went through a formal process to identify all the stakeholders involved with the chemical of concern, and in the cases where stakeholders were identified, stakeholders were not involved in the assessment. For example, the dry cleaner and chemical company considered how the alternative would impact the health of workers.

The line between this module and others, most notably the hazard and exposure assessment modules, is blurred, making it challenging to determine in which module certain considerations should be bucketed, to ensure they are not double counted. More information on this is included in the "IC2 AA Guide Gaps and Recommendations" section of this report.

Frameworks Module

Three possible frameworks for implementing the modules of the Guide are provided. While the three differ in approach, all achieve the objective of AA, i.e., identification of preferred alternatives that:

- *Pose less of a health concern than the chemical of concern.*
- *Pose less of an environmental or ecological concern than the chemical of concern.*
- *Either perform as effectively as the chemical of concern or meet desired performance requirements.*

Please see the IC2 Guide for descriptions of the three frameworks: simultaneous, sequential, and hybrid.

The dry cleaner is the only case study company that clearly followed one of the three frameworks presented in the Guide. The simultaneous framework was used as the cleaner evaluated the hazard, cost, performance, and exposure of alternatives simultaneously (Figure 1) before selecting alternatives for

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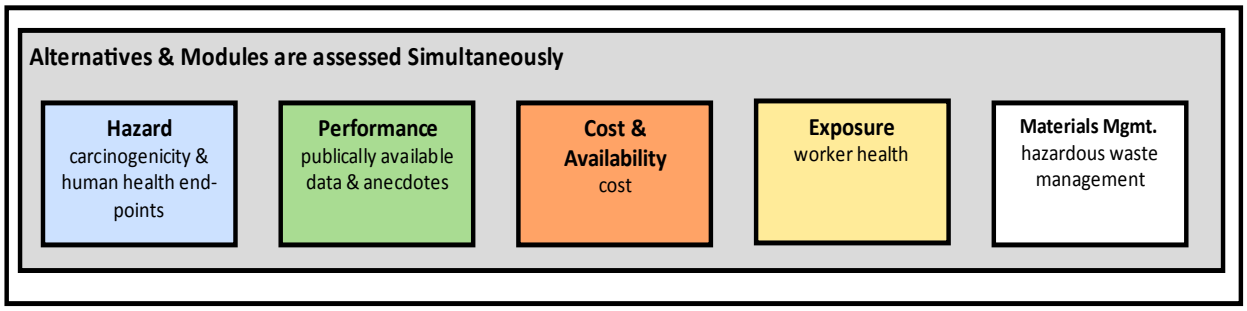
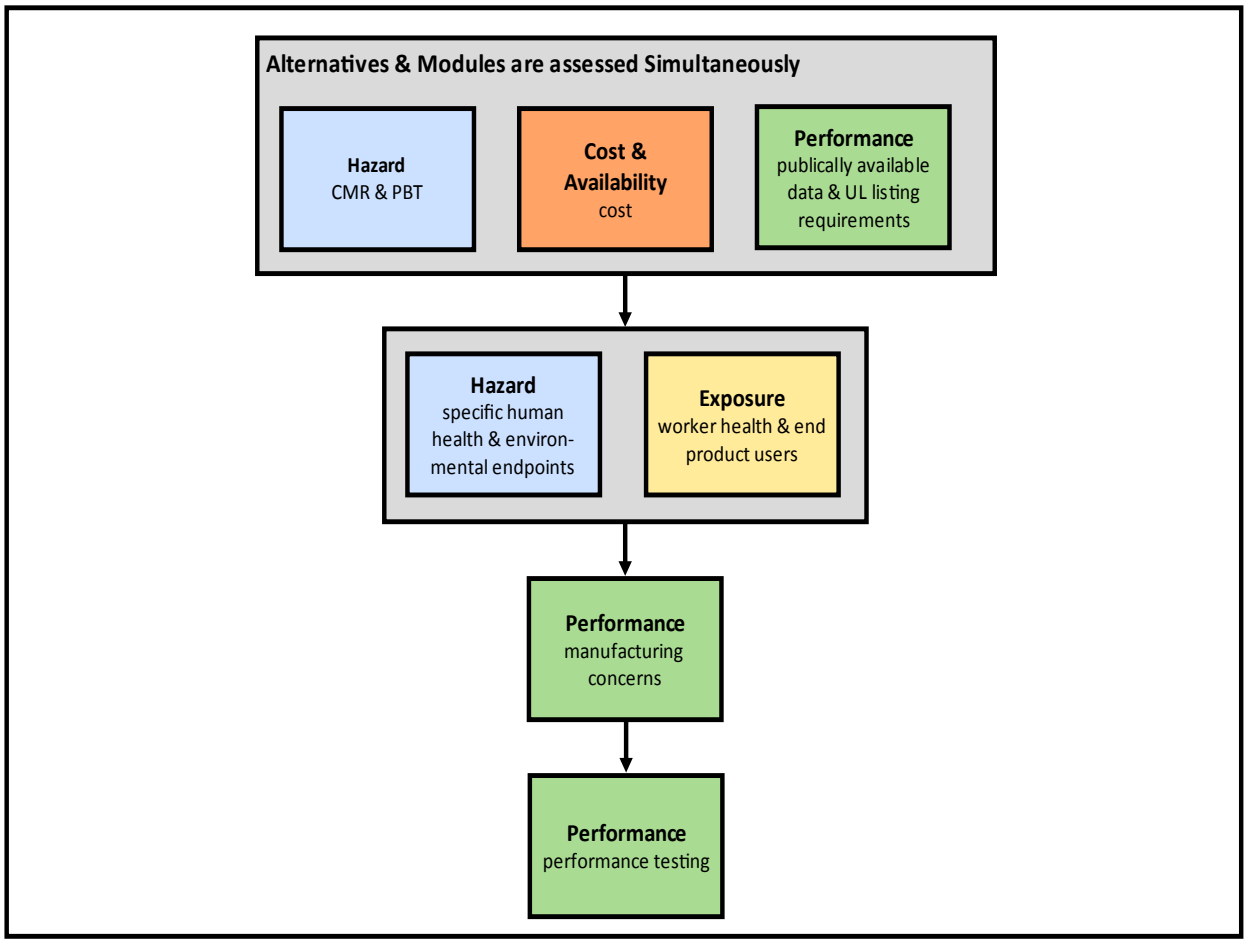
further investigation. The levels at which each of the modules were included in the AA varies and is discussed in the next section of this report.

Figure 1: Map of dry cleaner's AA process



In contrast, the AA process used by the plastic products manufacturer (Figure 2) and chemical company (Figure 3) did not specifically follow any of the three frameworks (i.e. simultaneous, sequential, or hybrid) though aspects of the frameworks were followed. The plastics products manufacturer loosely followed the hybrid framework. First, the hazard, cost and basic performance were evaluated, eliminating those alternatives that do not meet the requirements. Remaining alternatives were then evaluated based on their hazard, manufacturing concerns, and performance testing, in that order.

Figure 2: Map of plastic products manufacturer's AA process



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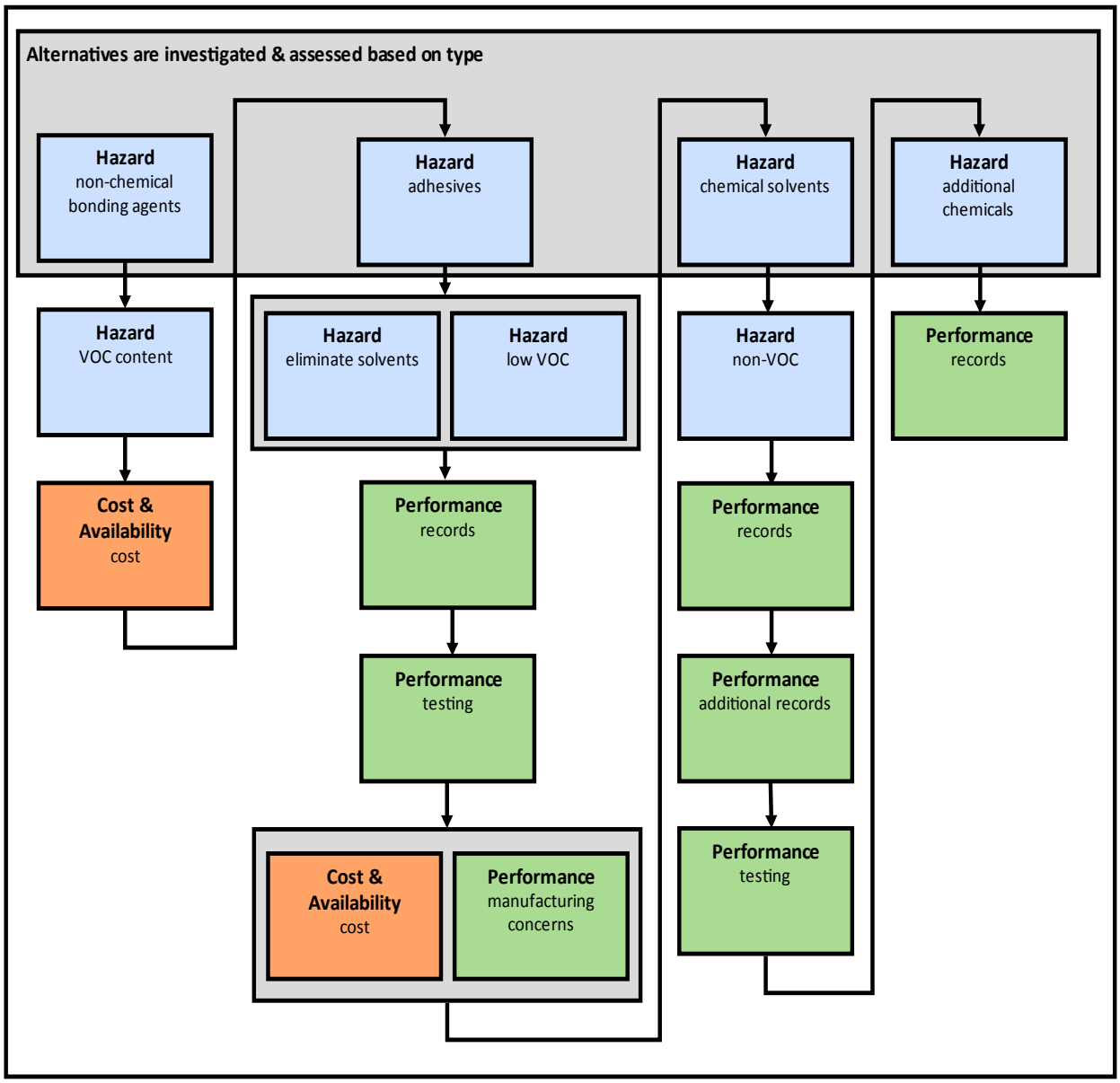
The chemical company followed a multistep framework, first categorizing alternatives based on basic hazard (i.e. non-chemical bonding agents, adhesives, chemical solvents, and additional chemicals). Those groups of alternatives were then evaluated based on a combination of additional hazard endpoints, cost, performance, and manufacturing concerns. The order in which the attributes were analyzed varied among the group of alternative types and priority was given to VOC content and compatibility with ABS plastic.

Figure 3: Map of chemical company's AA process



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Required Modules

Hazard Module In all three case studies, an *Initial Screen* was performed, using readily available data sources to evaluate the alternatives. The hazard endpoints included in the assessments were compared to "Table 5: Hazard Traits Evaluated for Levels 1-3" from the Guide below. While an *Initial Screen* was performed with all three companies, overall the companies did streamlined assessments. For example, in the plastic products manufacturer case, all of the Human Health endpoints were not specifically considered, but rather screened out alternatives that cause or are suspected of causing a significant human health effect. In contrast, the dry cleaner was specifically interested in carcinogenicity and other worker health effects, such as skin and respiratory sensitization. In all three cases, the significant hazard traits were determined while scoping the AA and none of the companies considered a comprehensive suite of end points. Interestingly, environmental endpoints were only considered in the plastics products manufacturer case.

Table 2. Hazard traits included in the case study companies' AAs

Hazard Traits evaluated & Data Sources consulted	**Levels**			**Case study companies**
	1	**2**	**3**	
Human Health				
Carcinogenicity	X	X	X	Dry Cleaner Plastic Manu.
Mutagenicity and Genotoxicity	X	X	X	Plastic Manu.
Reproductive Toxicity	X	X	X	Plastic Manu.
Developmental Toxicity (including Developmental Neurotoxicity)	X	X	X	
Endocrine Activity	X	X	X	
Acute Mammalian Activity	X	X	X	
Systemic Toxicity & Organ Effects (including Immonotoxicity)		X	X	
Neurotoxicity		X	X	Chemical Co.
Sensitization: skin		X	X	Dry cleaner
Sensitization: respiratory		X	X	Chemical Co. Dry cleaner
Ecological				Plastic Manu.
Acute aquatic toxicity	X	X	X	
Chronic aquatic toxicity		X	X	
Environmental				
Persistence	X	X	X	Plastic Manu.
Bioaccumulation	X	X	X	Plastic Manu.
Physical				Dry Cleaner
Reactivity		X	X	
Flammability		X	X	Chemical Co.
Additional environmental hazard traits				
Domesticated animal toxicity			X	
Eutrophication			X	
Impairment of waste management organisms			X	
Loss of genetic diversity, including biodiversity			X	
Phytotoxicity				
Wildlife developmental impairment			X	
Wildlife growth impairment			X	
Wildlife reproductive impairment			X	
Wildlife survival impairment			X	
Data Sources				
Authoritative Lists	X	X	X	Dry Cleaner Chemical Co.
GHS lists	X	X	X	

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Hazard Traits evaluated & Data Sources consulted	Levels			Case study companies
	1	2	3	
ECOTOX database	X	X	X	
EPA PBT profiler	X	X	X	
EU Risk Assessments	X	X	X	
OECD-IUCLID datasheets	X	X	X	
OECD-SIDS datasets	X	X	X	
RTECS	X	X	X	
TOXNET HSDB	X	X	X	
Review of scientific literature		X	X	Chemical Co. Plastic Manu.
Review of toxicological databases		X	X	
Review of QSAR analog information		X	X	
Professional judgement		X	X	Dry Cleaner Chemical Co. Plastic Manu.
Development of QSAR determination			X	
Development of laboratory studies			X	Chemical Co. Plastic Manu.
Peer review and validation of analysis			X	

Performance Evaluation Module. The dry cleaner used basic questions to determine performance of alternatives (Level 1). Both the plastic products manufacturer and chemical company used a mix of Levels 2 and 3, as they used technical quantitative information obtained from other sources (Level 2) as well as lab testing the alternatives (Level 3).

Cost and Availability Module. The dry cleaner used publically available data to determine if alternatives would be cost effective (Level 2). The plastic products manufacturer and chemical company used a mix of Levels 2 and 3, as they identified potential sources, prices, and availability of alternatives (Level 2) and evaluated the potential impact of cost on the entire product system (Level 3).

Exposure Assessment Module. The case study companies did not significantly evaluate exposure. The dry cleaner and plastic products manufacturer determined if there is a significant difference in the exposure scenarios of the alternative as compared to the chemical of concern (Initial Screen). The chemical company did not include a measure of exposure in their assessment.

Optional Modules

Materials Management Module. The dry cleaner and chemical company considered the raw materials used as well as the wastes generated (Level 1) while the plastic products manufacturer took the analysis a step further by evaluating the impacts associated with the raw materials (Level 2).

Social Impact Module. The dry cleaner and chemical company both considered potential impacts to the health of workers and the work environment (Level 1) while the plastic products manufacturer includes the potential impact to product users and the environment in general from use of the alternatives (Level 3).

Life Cycle Module. None of the case study companies used life cycle thinking or any other portions of the module in their assessment.

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4. IC2 AA Guide Gaps and Improvement Opportunities

Assessment criteria. Upon reviewing the case studies in this report, there did not appear to be attributes considered by the companies that were not included in the AA Guide.

Goal and scope definition. The goal and scope of an AA is critical as it frames the quantity, quality, and type of data that must be collected and used in the assessment. It also defines the criteria to be used in the assessment as well as the priority level for each. While the Guide lists the two steps in the AA process as "define the issue" and "identify the decision criteria", it does not explicitly discuss the need for clearly defining the goal and scope of the AA upfront. This is critical as the goal shapes the criteria used in the assessment as well as the priority levels of the criteria.

Opportunity for Improvement: Add the importance of a well-defined goal and scope, and direction to assist AA practitioners with defining both. Providing example goals and scopes would be beneficial.

The goal of an AA clearly defines the reason for performing the assessment, the intended audience for the study, and whether the results will be disclosed to the public, internally only, or shared with another group of stakeholders. The scope of an AA clearly defines the product system to be studied, any value choices or weighting that will be incorporated when making a decision, data quality requirements, and the type and format of the report. Many of the goal and scope requirements influence each other as well as the AA process, so it is important they are well defined before starting the AA.

The reason for performing the AA must be clear and can vary, such as to comply with regulatory requirements, customer request to remove the chemical of concern, manufacturing issue with the chemical of concern, worker health and/or safety concern, among others. Clearly defining the reason for the study will drive the criteria used in the assessment as well as the priority of the criteria when using the AA results to make decisions. Defining the intended audience for the study, such as regulators, the public, internal to a business, and the level at which results will be shared with different stakeholder groups will drive the modules to be included in the AA, the level at which the individual models are assessed, and, influence the type and format of the AA report. Understanding data quality requirements (i.e. is anecdotal evidence acceptable? or is performance testing required?) will affect the type and amount of data collected in the AA as well as the time and resources necessary to collect this data.

It is important to understand and clearly define the requirements of the AA up front to ensure that the AA results will meet the needs of the practitioner. Furthermore, when an AA is performed by a team, especially a team spread throughout multiple organizations, it is important to have a well-defined goal and scope to ensure everyone on the team is on the same page.

Potential double counting of impacts. The lines between many of the modules are blurred, making impact placement and assessment very difficult. For example, potential health effects of workers for a given alternative could conceivably fall under the Hazard, Exposure Assessment, or Social Impact Modules; however, only one should be chosen to avoid double counting of impacts. Inexperienced AA practitioners, such as those at a small or medium sized company, may struggle to bucket impacts into the correct module and inadvertently double count an impact (assess the same impact under multiple modules). The struggle to bucket the impacts into the correct module can be frustrating, time consuming, and detracts from the purpose of the AA by spending time and resources on an irrelevant task.

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Opportunity for Improvement: Develop a "cheat sheet" or table that clearly outlines the impacts that are included within each Module. This cheat sheet may be a short document, perhaps including examples, allowing a practitioner to quickly determine under which Module an impact falls.

Interpreting results and making decisions. The Guide intentionally does not address methods to interpret results and make decisions, leaving this portion of the process up to the user. It is important to remember that the Guide is just that – a guide or set of instructions defining what comprises an AA. Value judgments, which must be used when making a decision, are purposely left out of the Guide.

Opportunity for Improvement: Provide examples of frameworks or guidance that could be used to display and interpret results to facilitate decision making. Examples of methods to display results and help with decision making follow in the next section of this report.

Utility of the Guide with SMEs. As stated in the Guide, "The Guide is designed to meet the needs of a wide range of users, each with unique needs. As a result, the final product is complex and comprehensive.... Because of its breadth and complexity, the Guide may appear overwhelming. It is important to remember, however, that not all portions of the Guide may be used at any given time and no AA is expected to encompass all the modules and frameworks included." (pg2). The Guide also states that it was designed to "be flexible enough to meet a wide range of user needs including small, medium, and large businesses, local, state, and federal governments, and other interested parties" (pg1). The findings of this study suggest the AA Guide does not meet unique small and medium business user needs. Rather, the Guide meets the unique needs of relatively large companies and businesses who have the resources internally, or are able to obtain external resources (such as consultants) and have the time to comb through this complex and comprehensive process. In contrast, because smaller companies do not have the time or resources to complete this process the Guide lacks utility for these users.

Opportunity for Improvement: Develop a streamlined AA to meet the needs of smaller companies. The objective would be to develop an abbreviated guide that uses the AA Guide as a reference, consequently encouraging, rather than discouraging, the use of a systematic approach for AA. As the case study companies included in this report show, small and medium sized companies are performing AAs, typically without the use of a structured format. A streamlined AA would provide a simple framework for companies to perform an AA, ensuring that relevant attributes are included in the AA. The streamlined AA would target small and medium sized businesses and include:

- Basic outlines of the Guide's modules for consideration in performing an AA,
- Higher level guidance and references to the Guide for each module, allowing companies to dive deeper only as needed,
- Guidance on how to compile all data and modules to assist in decision making, and
- Consist of only a few pages.

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5. Displaying Results to Facilitate Decision Making

Methods to display results

While performing the case study analysis presented in this report, it was clear that the Guide is lacking methods and/or models to display the Guide results, which would facilitate ease of interpretation and decision making. While the Guide is extremely comprehensive in including all possible considerations in the AA, the amount of information amassed throughout this process is substantial. Furthermore, there is a mix of qualitative and quantitative data. Placing this data into a framework for analysis would provide a more manageable, organized presentation to work with.

Opportunity for Improvement: Multiple recommended methods to display AA Guide results are provided below. All methods assume that the goal and scope of the AA have been well defined upfront.

1. **Develop a set of "yes/no" or "pass/fail" criteria** for each of the modules to be included in the analysis and perform the AA for the chemical of concern as well as the alternatives. This allows the user to quickly see which alternatives meet the criteria within each module. It is important to note that this method does not account for the level at which an alternative meets the criteria (i.e. an alternative that costs the same and an alternative that costs 10% less both may meet the criteria, but there's no way to indicate that one is preferable). This method may best be suited for a preliminary screen of alternatives.
2. **Determine criteria for each of the modules and evaluate them relative to the alternative, using a system of +/=/- or >/=/<.** This process is relatively straight forward and will allow the user to quickly identify those alternatives that are better than the chemical of concern and any potential hot spots, or areas where a seemingly favorable alternative is not actually favorable, for further investigation. This method is best suited for a preliminary screen of alternatives.
3. **Develop a set of high/moderate/low criteria** for each of the modules to be included in the analysis and perform the AA for the chemical of concern as well as the alternatives. This process is used by the EPA Design for Environment Program to perform the hazard evaluation portion of the AA and criteria can be found in "Design for the Environment Program Alternatives Assessment Criteria for Hazard Evaluation". This process will take considerable time to both set up the criteria as well as perform the analysis and may best be suited for assessing remaining alternatives that pass a preliminary screening.

Facilitating Decision Making

Once the preliminary screening or comprehensive assessment has been completed and the results have been compiled, the user must make a decision to determine which alternative(s) is the most preferable. While the Guide mentions methods used to address complex decisions, the methods are described somewhat vaguely and do not describe *how* to implement them and actually make decisions.

Ultimately, the user must determine the importance of all criteria included in the screening/assessment and assign a weighting factor based on this level of importance. Value judgements are inherently a part of this process so transparency and documentation of the weighting and judgements used is critical. Often after collecting data for the assessment, it isn't clear exactly which alternative is preferable and weights are applied. Adjusting the weighting factors could therefore change the outcome of the assessment.

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This further illustrates the importance of having a clear goal and scope defined at the very beginning of the AA. Any weighting and prioritization of modules or specific impacts will be defined upfront, allowing the practitioner to present the results in accordance with the prioritization already established.

Opportunity for Improvement: While there are multiple ways in which a weighting factor can be applied to the AA results, it is important to note that the weights assigned to criteria are based on the goal and scope of the assessment. It's critical that the goal is well defined and the answers to "what is a safer alternative?", "what criteria are critical that the alternative meet?", and "what criteria are preferable?" are clear as these answers will drive how the criteria are prioritized. Furthermore, the user should also ask how much risk, if any, the assessor is willing to take within each criteria group. Defining, for example, how much more you are willing to spend on an alternative than initially expected if the hazard is significantly reduced, will further help prioritize the criteria. Two methods for prioritization are provided below.

1. **Determine high/moderate/low priority criteria and screen out alternatives based on high priority criteria**, then moderate, and finally low priority criteria. This is similar to the process that the GreenScreen® for Safer Chemicals uses with their Benchmarks™ when assessing the hazard associated with chemicals.
2. **Determine high/moderate/low priority criteria and assign numerical values to them** (such as 1, 2, 3). The values are added to rank the alternatives.

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6. Priority Improvement Areas

A number of opportunities for improvement have been identified throughout this report. The three opportunities below are those which the NYSP2I believes to be of most value to users of the AA Guide at this time.

1. **Goal and scope guidance**

   The goal and scope of an AA is critical as it frames the quantity, quality, and type of data that must be collected and used in the assessment. It also defines the criteria to be used in the assessment as well as the priority level for each. While the Guide lists the two steps in the AA process as "define the issue" and "identify the decision criteria", it does not explicitly discuss the need for clearly defining the goal and scope of the AA upfront. This is critical as the goal shapes the criteria used in the assessment as well as the priority levels of the criteria, which in turn drives how the results are displayed and the decision to move forward with an alternative is made.

   Creation of a guidance document that explains the process and considerations when crafting the goal and scope of an AA would be very beneficial. Practical examples of both well thought out and poor goals and scopes will provide useful guidance to practitioners.

2. **Streamlined AA process for SMEs**

   While each user of the Guide has a unique need, the Guide does not meet all of them. Rather, the Guide meets the unique needs of relatively large organizations that have the resources internally, or are able to obtain external resources (such as consultants) and have the time and expertise to comb through this complex and comprehensive process. In contrast, the Guide lacks utility for smaller companies who do not have the time, expertise, or resources to complete the process outlined in the Guide and for situations where a shorter, more streamlined approach to the AA is appropriate.

   Development of a streamlined AA process will better meet the needs of smaller companies. This streamlined AA would be an abbreviated version of the Guide that uses the current AA Guide as a reference, consequently encouraging, rather than discouraging, the use of a systematic approach for AA. As the case study companies included in this report show, small and medium sized companies are performing AAs, typically without the use of a structured format. A streamlined AA would provide a simple framework for companies to perform an AA, ensuring that relevant attributes are included in the AA.

   In addition, a "cheat sheet" or table that clearly outlines the impacts included within each Module of the Guide would be helpful. This cheat sheet may be a short document that allows a practitioner to quickly determine under which Module an impact falls and provide a reference to ensure all relevant impacts are included in the AA.

3. **Guidance to display results**

   Multiple methods to display AA Guide results were developed and are presented in this report. All methods assume that the goal and scope of the AA have been well defined upfront.

   A. **Develop a set of "yes/no" or "pass/fail" criteria** for each of the modules to be included in the analysis and perform the AA for the chemical of concern as well as the alternatives. This allows the user to quickly see which alternatives meet the criteria within each module. It is important to note that this method does not account for the level at which an alternative meets the criteria. *This method may best be suited for a preliminary screen of alternatives*.

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B. **Determine criteria for each of the modules and evaluate them relative to the alternative, using a system of +/=/- or >/=/<.** This process is relatively straight forward and will allow the user to quickly identify those alternatives that are better than the chemical of concern and any potential hot spots, or areas where a seemingly favorable alternative is not actually favorable, for further investigation. *This method is best suited for a preliminary screen of alternatives.*

C. **Develop a set of high/moderate/low criteria** for each of the modules to be included in the analysis and perform the AA for the chemical of concern as well as the alternatives. This process is used by the EPA Design for Environment Program to perform the hazard evaluation portion of the AA and criteria can be found in "Design for the Environment Program Alternatives Assessment Criteria for Hazard Evaluation". This process takes considerable time to set up the criteria as well as perform the analysis. *This method may best be suited for assessing remaining alternatives that pass a preliminary screening.*

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