Policies Informed by Greener Chemistry, How to Accelerate Application of Safer Processes

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Overview

- Why alternatives assessment
- What is alternatives assessment
  - Definitions and frameworks
  - Goals and considerations
- Principles and main elements of alternatives assessment
- Evolution of the scientific literature on alternatives assessment
- Policies and applications of alternative assessments
- Example: Massachusetts Toxics Use Reduction Institute's approach
- Moving from alternatives assessment to green chemistry
- Lessons learned and additional resources

About me…

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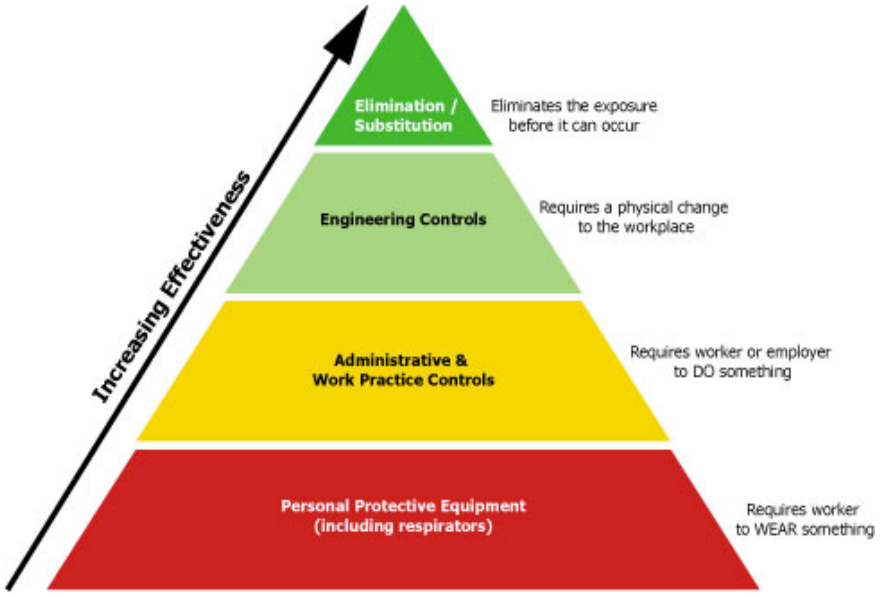
GC3 GREEN CHEMISTRY & COMMERCE COUNCIL

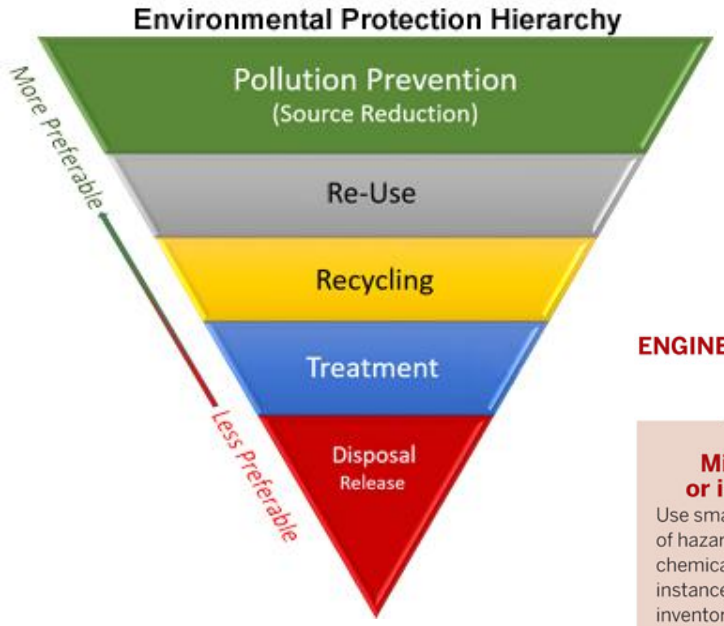
TURI TOXICS USE REDUCTION INSTITUTE UMASS LOWELL

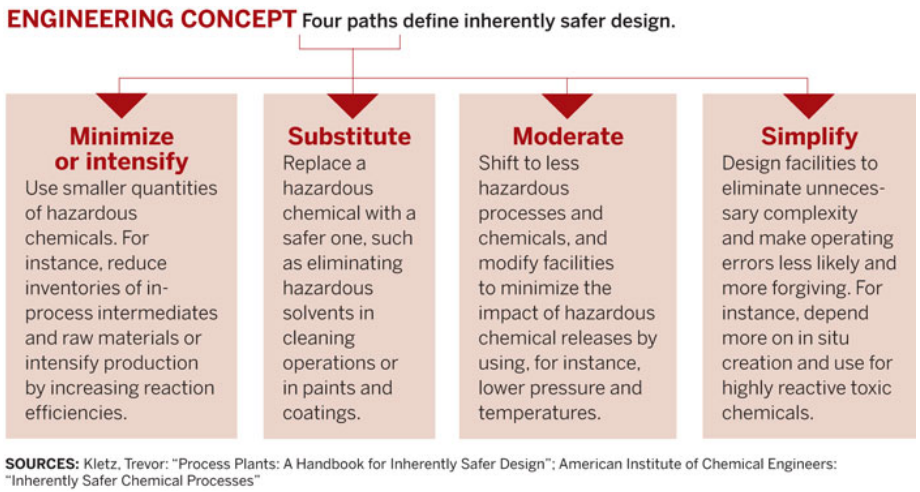
Drivers of safer chemicals

- Impacts/clean up costs of existing problem chemistries
- Legislation/regulations
- Market demand to “avoid” chemicals of concern
- Consumer advocacy
- Evolution of science/tools
- Increasing focus on sustainability, circularity and potential trade-offs

The focus on safer chemistry is consistent with years of practice in chemicals management and essential for effective product stewardship







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Starting point for transitioning to safer chemistry

- Know what's in it
- Know function and application
- Know hazards and potential exposures and other "concerns"

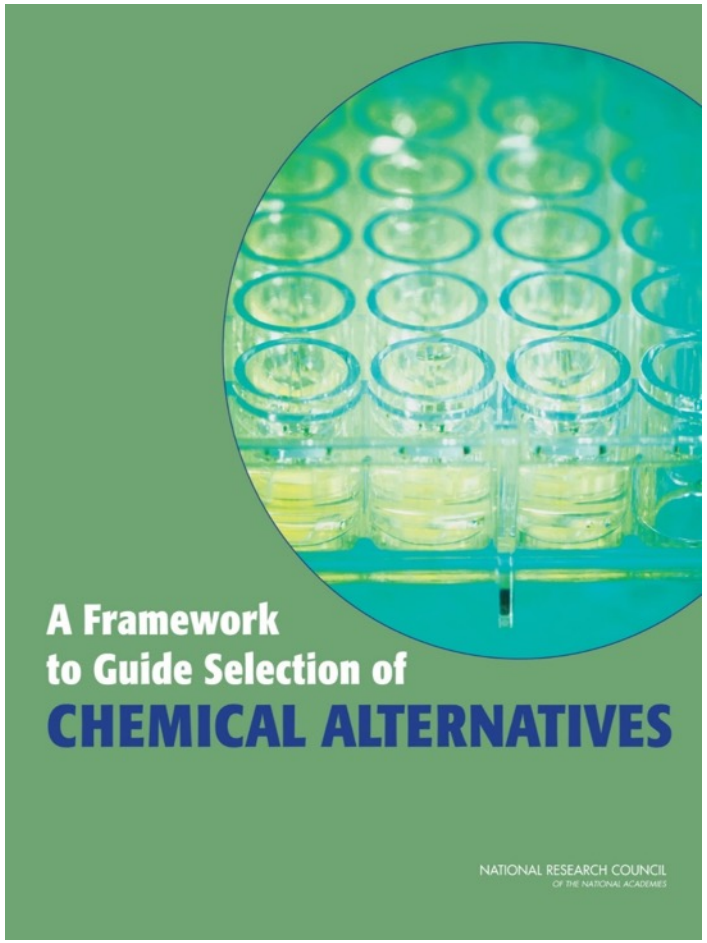
Then….

- Thoughtfully compare options (including trade-offs) to meet a particular functional need – alternatives assessment
- If better options don't exist, employ tools of green chemistry to design new ones

What is alternatives assessment?

"A process for identifying, comparing, and selecting safer alternatives to chemicals of concern on the basis of their hazards, comparative exposure, performance, and economic viability"

- NAS 2014



NAS 2014: Alternatives Assessment

Is:

- is a process for identifying, comparing and selecting safer alternatives to chemicals of concern.
- has a goal of facilitating an informed consideration of the advantages and disadvantages of alternatives to a chemical of concern.

Is not:

- a *safety assessment*, where the primary goal is to ensure that exposure is below a prescribed standard.
- a *risk assessment* where risk associated with a given level of exposure is calculated.
- a *sustainability assessment* that considers all aspects of a chemicals' life cycle, including energy and material use.

Goal is Informed Substitution

EPA - 2010

A considered transition from a chemical of particular concern to safer chemicals or non-chemical alternatives.

The goals of informed substitution are to:

- Minimize the likelihood of unintended consequences, which can result from a precautionary switch away from a chemical of concern without fully understanding the profile of potential alternatives (including performance), and
- Enable a course of action based on the best information - on the environment and human health - that is available or can be estimated.

Regrettable Substitutions

A Few Examples

EDF Health

About this blog

Science, health, and business experts at Environmental Defense Fund comment on chemical and nanotechnology issues of the day.
Our work: Chemicals

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Search

Regrettable, if predictable: Bisphenol S mimics estrogen just like its better-studied cousin, bisphenol A

By RICHARD DENISON | BIO | Published: JANUARY 17, 2013

Richard Denison, Ph.D., is a Senior Scientist.

A rule of thumb in chemistry is that chemicals that look alike will more often than not act alike. (If it looks like a duck ... .) Indeed, when chemical companies are faced with testing requirements for one of their chemicals, they routinely argue that they should be allowed to submit test data on a structurally related chemical instead.

So when it was revealed that companies making products (such as thermal receipt paper) that contain the estrogen-mimicking compound bisphenol A (BPA) were switching to another chemical called bisphenol *S* (BPS), many scientists' eyebrows quickly arched.

Take a look at these two chemical structures:

Methylene chloride & 1-Bromoproane (NPB)

Lynne Peeples Become a fan
lynne.peeples@huffingtonpost.com

New Flame Retardants, Other Replacement Chemicals, Pose Same Problems As Predecessors

Posted: 11/28/2012 12:04 pm EST | Updated: 11/28/2012 10:06 pm EST

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Focus of Alternatives Assessment

Alternatives assessment is a step-defined, action-oriented process

- Focus on function not the particular chemical
  - Focus on "intrinsic impact reduction"
  - Considers the "necessariness" of a chemical
- Finding a safer alternative and getting industry to adopt the use of it are not the same thing.
  - Must also be affordable and effective
- In some cases, safer, feasible alternatives may not exist and need to be developed

Function

The starting point of Alternatives Assessment

Tickner, et al, Environmental Science and Technology, 2014

Table 1. Functional Substitution for Chemicals in Products, Chemicals in Processes

Functional Substitution Level	**Chemical in Product** Bisphenol-a in Thermal Paper	**Chemical in Process** Methylene Chloride in Degreasing Metal Parts
Chemical Function (Chemical Change)	Is there a functionally equivalent chemical substitute (i.e., chemical developer)? **Result: Drop-in chemical replacement**	Is there a functionally equivalent chemical substitute (i.e., chlorinated solvent degreaser)? **Result: Drop-in chemical replacement**
End Use Function (Material, Product, Process Change)	Is there another means to achieve the function of the chemical in the product (i.e., creation of printed image)? **Result: Redesign of thermal paper, material changes**	Is there another means to achieve the function of the process (i.e., degreasing)? **Result: Redesign of the process** (e.g., ultrasonic, aqueous)
Function As Service (System Change)	Are cash register receipts necessary? Are there alternatives that could achieve the same purpose (i.e. providing a record of sale to a consumer)? **Result: Alternative printing systems** (e.g., electronic receipts)	Is degreasing metal parts necessary? Are there other alternatives that could achieve the same purpose (i.e., providing metal parts free of contaminants for other end uses)? **Result: Alternative metal cutting methods**

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Three Essential Steps of Alternatives Assessments (O'Brien 2000)

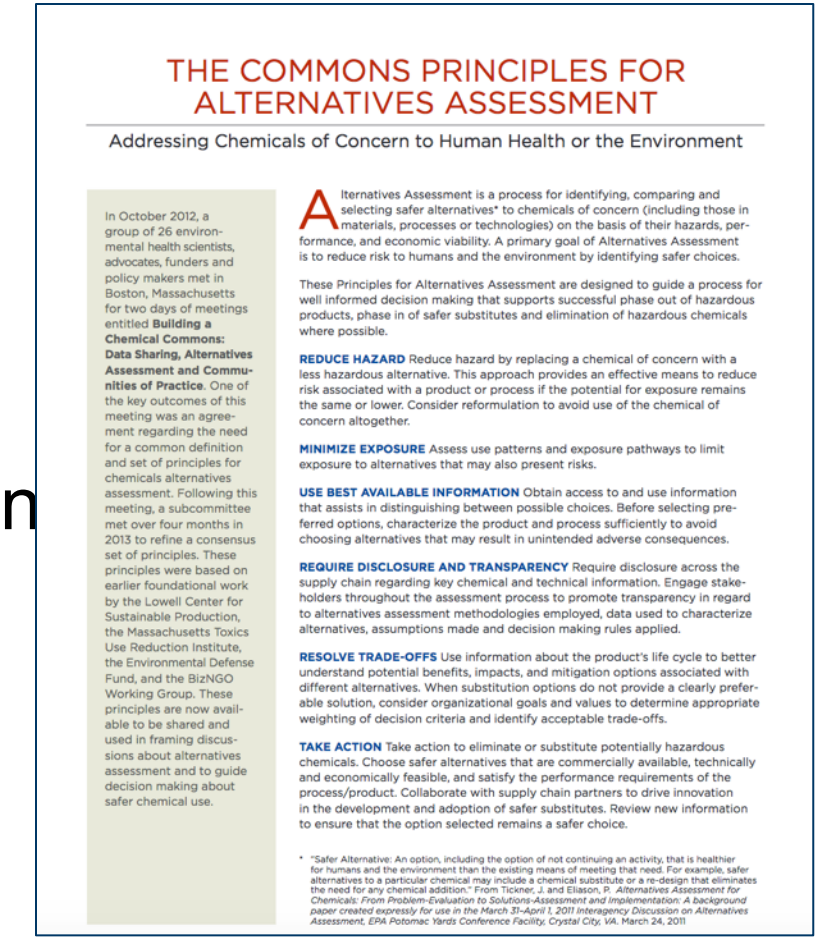
"One of the most essential, and powerful steps to change is understanding that there are alternatives"

1. Presentation of a full range of alternatives
2. Presentation of the potential adverse effects of each option
3. Presentation of potential benefits of each option

Commons Principles for Alternatives Assessment

www.bizngo.org/alternatives-assessment/commons-principles-alt-assessment

- Reduce Hazard
- Minimize Exposure
- Use Best Available Information
- Require Disclosure and Transparen
- Resolve Trade-Offs
- Take Action



THE COMMONS PRINCIPLES FOR ALTERNATIVES ASSESSMENT

Addressing Chemicals of Concern to Human Health or the Environment

In October 2012, a group of 26 environmental health scientists, advocates, funders and policy makers met in Boston, Massachusetts for two days of meetings entitled **Building a Chemical Commons: Data Sharing, Alternatives Assessment and Communities of Practice**. One of the key outcomes of this meeting was an agreement regarding the need for a common definition and set of principles for chemicals alternatives assessment. Following this meeting, a subcommittee met over four months in 2013 to refine a consensus set of principles. These principles were based on earlier foundational work by the Lowell Center for Sustainable Production, the Massachusetts Toxics Use Reduction Institute, the Environmental Defense Fund, and the BizNGO Working Group. These principles are now available to be shared and used in framing discussions about alternatives assessment and to guide decision making about safer chemical use.

Alternatives Assessment is a process for identifying, comparing and selecting safer alternatives* to chemicals of concern (including those in materials, processes or technologies) on the basis of their hazards, performance, and economic viability. A primary goal of Alternatives Assessment is to reduce risk to humans and the environment by identifying safer choices.

These Principles for Alternatives Assessment are designed to guide a process for well informed decision making that supports successful phase out of hazardous products, phase in of safer substitutes and elimination of hazardous chemicals where possible.

REDUCE HAZARD Reduce hazard by replacing a chemical of concern with a less hazardous alternative. This approach provides an effective means to reduce risk associated with a product or process if the potential for exposure remains the same or lower. Consider reformulation to avoid use of the chemical of concern altogether.

MINIMIZE EXPOSURE Assess use patterns and exposure pathways to limit exposure to alternatives that may also present risks.

USE BEST AVAILABLE INFORMATION Obtain access to and use information that assists in distinguishing between possible choices. Before selecting preferred options, characterize the product and process sufficiently to avoid choosing alternatives that may result in unintended adverse consequences.

REQUIRE DISCLOSURE AND TRANSPARENCY Require disclosure across the supply chain regarding key chemical and technical information. Engage stakeholders throughout the assessment process to promote transparency in regard to alternatives assessment methodologies employed, data used to characterize alternatives, assumptions made and decision making rules applied.

RESOLVE TRADE-OFFS Use information about the product's life cycle to better understand potential benefits, impacts, and mitigation options associated with different alternatives. When substitution options do not provide a clearly preferable solution, consider organizational goals and values to determine appropriate weighting of decision criteria and identify acceptable trade-offs.

TAKE ACTION Take action to eliminate or substitute potentially hazardous chemicals. Choose safer alternatives that are commercially available, technically and economically feasible, and satisfy the performance requirements of the process/product. Collaborate with supply chain partners to drive innovation in the development and adoption of safer substitutes. Review new information to ensure that the option selected remains a safer choice.

* "Safer Alternative: An option, including the option of not continuing an activity, that is healthier for humans and the environment than the existing means of meeting that need. For example, safer alternatives to a particular chemical may include a chemical substitute or a re-design that eliminates the need for any chemical addition." From Tickner, J. and Eliason, P. *Alternatives Assessment for Chemicals: From Problem-Evaluation to Solutions-Assessment and Implementation: A background paper created expressly for use in the March 31–April 1, 2011 Interagency Discussion on Alternatives Assessment, EPA Potomac Yards Conference Facility, Crystal City, VA.* March 24, 2011

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Table 1. Elements of AA—A snapshot

	Component	What it involves
Assessment	Scoping, problem formulation	– Establishes the scope and plan for the assessment – Identifies stakeholders to engage and the decision rules that will guide the assessment – Gathers data on the chemical of concern, its function and application
	Identify alternatives	– Identifies alternatives to be considered based on the functional needs in the application currently being performed by the chemical of concern
	Hazard assessment	– Evaluates the human health and ecological hazards for each alternative compared to the chemical of concern
	Exposure characterization	– Evaluates the intrinsic exposure potential for each alternative on the basis of boundaries established in the problem formulation step
	Technical feasibility assessment	– Assesses the performance of alternatives against the requirements established during the problem formulation step
	Comparative economic feasibility assessment	– Assesses the economic feasibility of alternatives against the requirements established during the problem formulation step
	Other life cycle considerations	– Addresses additional factors critical for characterizing effects to human health and the environment beyond those included in the hazard and exposure assessment component to avoid risk trade-offs (e.g., energy, climate change effects, etc.)
	Decision making	– Identifies acceptable alternatives on the basis of information compiled in previous steps – Addresses situations in which no alternatives are currently viable by initiating research and development to generate new alternatives or improve existing options – Establishes an implementation plan
Action	*Adoption*	– Implementation of the safer, feasible alternative and identification of any potential trade-offs and continuous improvement opportunities
	Link to safer chemistry and/or technology research and development	– When no safer, feasible alternative is identified, research and development should be initiated

Source: Expands on the NRC (2014) framework by including additional details on technical, economic assessment and decision making that is inclusive of other AA frameworks, such as the Interstate Chemicals Clearinghouse Alternatives Assessment Guidance, V. 1.1 (IC2 2017).

Source:
Tickner et al. IEAM 2018

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AA Methods and Tools

Comparative Hazard Assessment	• Most developed • Data gaps remain a challenge
Economic Assessment	• More "academic" socio-economic analysis methods available, but difficult for SMEs to use • Limited tools
Technical Performance	• Very limited • Case/application-specific

Lifecycle considerations, comparative exposure characterization and decision analysis, but tools specific for AA limited.

Landscape of Hazard Assessment Tools (Not comprehensive, or mutually exclusive)

Connector tools

- ChemSec's Market Place
- CleanGredients

Restricted/ preferred lists

- SIN List
- Sector-based lists (e.g., Global Automotive Declarable List)
- US EPA Safer Chemical Ingredient List

Screening tools

- GreenScreen List Translator
- PRIO
- RISTOX
- SINimilarity
- UL The Wercs

Comparative assessment tools

- GreenScreen®
- Quick Chemical Assessment Tool (QCAT)
- SciveraLENS
- Column Model
- P2OASys

Data tools

- ECHA data
- Data Commons
- OECD QSAR Toolbox
- EPI Suite

OECD

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OECD Substitution and Alternatives Assessment Tool Selector

The Tool Selector is designed to provide information on tools that can be used in conducting chemical substitutions or alternatives assessments. The filters below may be used to identify tools of greatest relevance to your substitution or alternatives assessment goals. You may also view more in-depth information on each tool, or a side-by-side comparison of a set of tools, by selecting two or more tools from the list below.

What's an Alternatives Assessment Tool?

A tool is an approach for evaluating a chemical, material, process, product, and/or technology for attribute analysis within a chemical substitution/alternatives assessment.

All tools included in the Tool Selector address **chemical hazard assessment**, and may address other comparative attributes.

Tools that contain a repository of organized information but do not have a mechanism for data manipulation for outside users are flagged below as data sources using the following symbol: (DS)

For information on tools with a primary focus on non-hazard comparative attributes such as cost/benefits and availability, life-cycle impacts, and materials management, please visit the Inventory of Non-Hazard Assessment Tools.

Each tool has its benefits and limitations. The user of this toolbox needs to understand the capabilities of the tools to make the most informed decisions about conducting alternatives assessments.

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There is a need to address remaining gaps in methods and practice and build a community of practice

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Decision Analysis

Advancing Alternatives Assessment for Safer Chemical Substitution: A Research and Practice Agenda

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ABSTRACT

Alternatives assessment has emerged as a science policy field that supports the evaluation and adoption of safer chemistries in manufacturing processes and consumer products. The recent surge in the development and practice of alternatives assessment has revealed notable methodological challenges. Spurred by this need, we convened an informal community of practice comprising industry experts, academics, and scientists within government and nongovernmental organizations to prioritize a research and practice agenda for the next 5 years that, if implemented, would significantly advance the field of alternatives assessment. With input from over 40 experts, the agenda outlines specific needs to advance methods, tools, and guidance in 5 critical areas: hazard assessment, comparative exposure characterization, life cycle considerations, decision making, and professional practice. Fifteen research and practice needs were identified, ranging from relatively simple efforts to define a minimum hazard data set to the development of more complex performance and decision-analytic methods and data

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Alternatives Assessment in Policy

Regulatory policies
- Require alternatives assessment to demonstrate availability or lack of safer feasible alternatives to a chemical of concern (REACH, CA SCP)
- Require alternatives assessment to support regulatory actions (WA, ME, OR)
- Integrate safer alternatives considerations in procurement (SF)
- Require facility planning that examines alternatives (MA TURA)
- Classification-based substitution requirements (EU occupational)
Non-regulatory programmatic support policies
- Conduct assessments for priority chemicals (WA, EPA DfE, TURI)
- Provide technical support, demonstration, networking, training (TURI)
- Provide data, positive listing, labeling (EPA Safer Choice)

Addressing adoption of safer alternatives – the Massachusetts Toxics Use Reduction Institute approach

- Train professionals on how to do assessments, providing tools
- Evaluate alternatives to chemicals of concern in the state
- Support supply chain engagement to address adoption challenges
- Fund collaborative research to identify safer, cost-effective new technology options.

Tools for Finding and Assessing Safer Solvent Alternatives

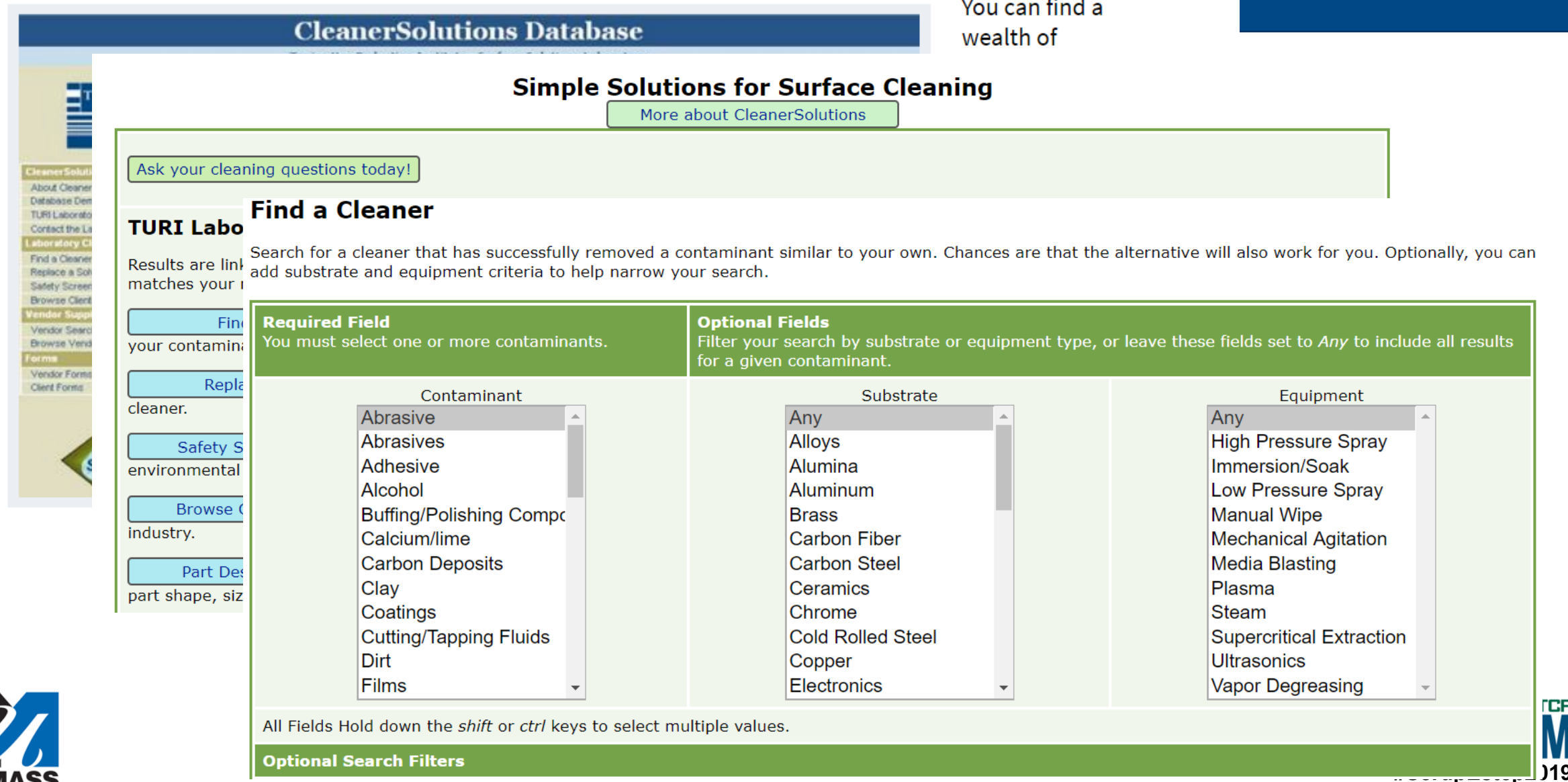
Identifying safer parts cleaning solutions: www.cleanersolutions.org

Gathering data to support evaluation process: http://guides.turi.org/beyondmsds

Comparing chemical, product and process alternatives: https://p2oasys.turi.org/

CleanerSolutions.org

You can find a wealth of



What is P2OASys?

P2OASys allows companies to assess the potential environmental, worker, and public health impacts of alternative technologies aimed at r
systematic thinking about the potential hazards posed by current and alternative processes identified during the TUR planning process. Th

Systematically examine the potential environmental and worker impacts of options, examining the total impacts of process changes,

Compare options with current processes based on quantitative and qualitative factors.

Embedded formulas in P2OASys provide a numerical hazard score for the company's current process and identified options, which can the
expertise to make decisions on adoption of alternatives. Companies input both quantitative and qualitative data on the chemical toxicity, e
organization likely as a result of the proposed option.

Any question or comments can be directed at Jason Marsh

TURI
TOXICS USE REDUCTION INSTITUTE
UMASS LOWELL
CLEANING LABORATORY

Jason Marshall:
Tel:(978) 934-3133
Email: Jason@turi.org

This web site is maintained by the Toxics Use Reduction Institute at the
The Massachusetts Toxics Use Reduction I
University of Massachusetts Lowell
600 Suffolk Street
Lowell, Massachusetts 01854-2866
Tel: 978-934-3275 Fax: 978-934-3050

Welcome to the P2OASys Tool!

Information about P2OASys can be found on the TURI webpage here.

Create New Assessment | Load From P2OASys Database

Name	P2OASys Format	SDS Format	Remove
Sample Chemical	Enter Data	Enter Data	Remove

Assessment Score Summary | Compare Entered Data

Upload A Chemical/Product to the P2OASys Database

Upload A Mixture to the P2OASys Database

Export Data to CSV | Import Data from CSV

Hazard Score Matrix

https://p2oasys.turi.org/

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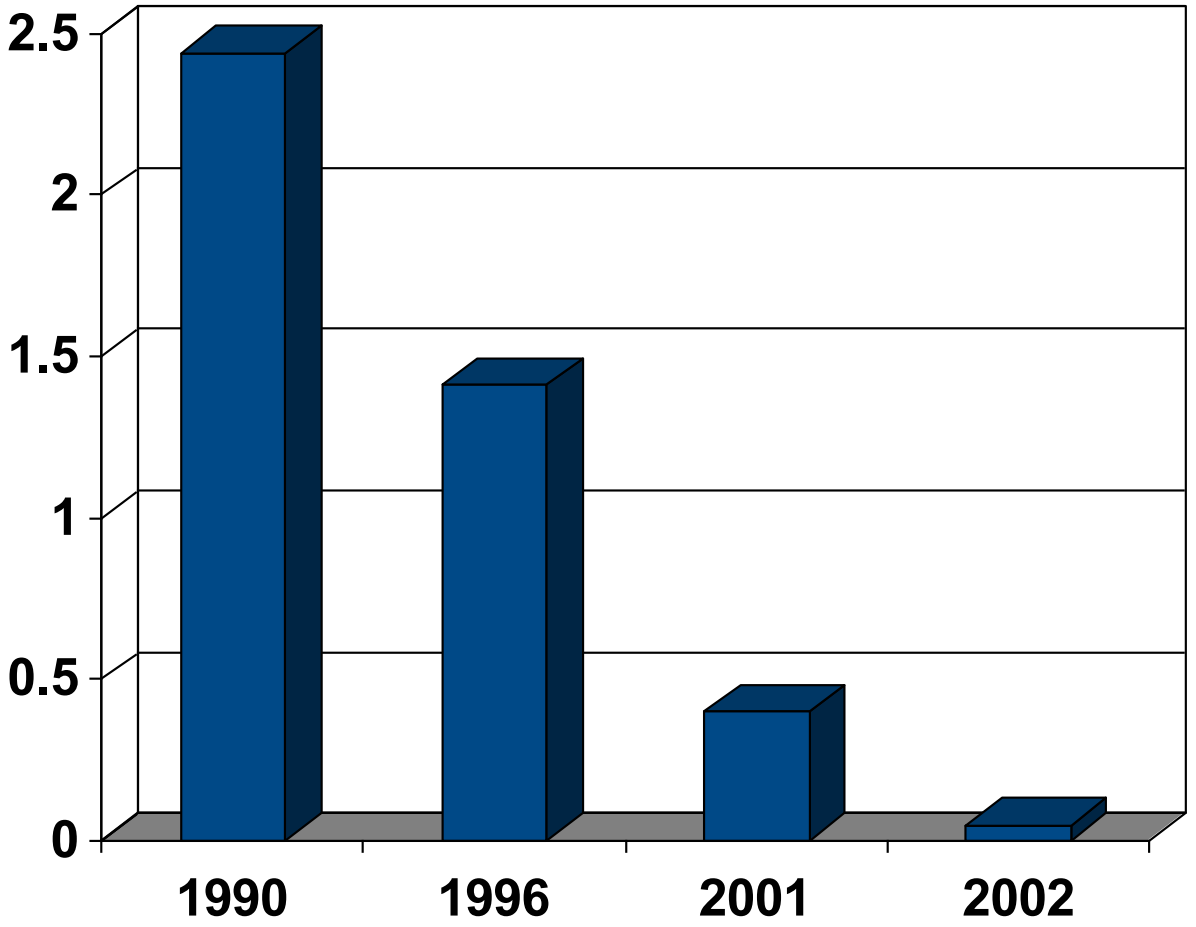
Case Study: Trichloroethylene

The Result of the Massachusetts Toxics Use Reduction Planning and Technical Support Process



Trichloroethylene Cleaning Use Data

millions of pounds

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Case Study: Perchloroethylene

Uses in Massachusetts

- **Garment cleaning (professional dry cleaning)**
- Industrial vapor degreasing
- Automotive aerosols

Why Higher Hazard Substance

- Neurotoxin
- Skin and eye irritant; Causes defatting of skin
- Liver, Kidney and CNS damage
- Carcinogen (NTP: Reasonably anticipated to be a human carcinogen; IARC Group 2A Probably carcinogenic to humans)
- Toxic to aquatic organisms

http://www.turi.org/TURI_Publications/TURI-Methods-Policy-Reports/Assessment_of_Alternatives_to_Perchloroethylene_for_the_Dry_Cleaning_Industry

Alternatives Evaluated

- n Propyl bromide
- Siloxane (D5)
- Propylene glycol ethers
- Acetal (Solvon K4)
- High flashpoint hydrocarbons
- Liquid CO_2
- Wet Cleaning

Summary Table: Comparison of Perc and Seven Garment Cleaning Alt

Key Assessment Criteria		Perc (reference)	Wet Cleaning[1]	Carbon Dioxide	High Flashpoint Hydrocarbons	Acetal	Propylene Glycol Ethers	Siloxane	n Propyl Bromide
Common Trade Names / Manufacturers of Equipment or Solvents			Wascomat, Miele, Continental, HwaSung, AquaSolo	Cool Clean Technologies, Solvair®	DF2000™ Fluid, EcoSolv®, ShellSol D60, Caled Hydroclene	Solvon K4	Solvair®, Rynex 3®, Impress®, Gen-X®	Green Earth® D5 solvent	Drysolv®, Fabrisolv™ XL
Solvent Chemical Identification [CAS#]		Perchloroethylene [127-18-4]	Solvent: Water Detergents: See full report[1]	Carbon Dioxide [124-38-9]	Naphtha (petroleum) hydrotreated heavy [64742-48-9]; C10-C13 Isoalkanes [68551-17-7]	1-(butoxy methoxy) butane (butylal) [2568-90-3]	dipropylene glycol tert-butyl ether, [132739-31-2]; di-propylene glycol n-butyl ether, [29911-28-2]	Decamethylcyclo-penta siloxane (D5) [541-02-6]	N Propyl Bromide (nPB) [106-94-5]
Technical / Performance[2]	Cycle time (min)	45	20-40	35-45	60-75	60-65	>45	53-58	45
	Load capacity (lb)	50	20-75	60	35-90	40-90	43	55	50
	Materials system may have difficulty with	Leather, suedes, beads, delicates	Leather, suede and fur	Triacetates, specially dyed acetates	Vinyl appliqués	Appliqués or decorations glued to fabric	None identified	None identified	Leather, suedes, beads, delicates
	Spotting requirements	Moderate	Low	High	Moderate	Low	Low	High	Low
Financial	Equipment	$40,000 - $65,000	$36,000 - $61,000	$100,000 - >$150,000	$38,000 - $75,000	$50,000 - $100,000	$56,000	$30,500 - $55,000	$40,000 - $60,000 or retrofit costs
	Chemical cost per gallon	$17	$0.007/gal (water); $25-$31/gal (detergent)	$0.18/lb ($CO_2$); $40/gal (detergent)	$14-$17	$28-$34	$25-$30	$22-$28	$40-$64
	Electricity usage[3] (kWh/100 lb)	26.6	9.3	30.9	35.5	Similar to hydrocarbon	Unavailable	54.2	Unavailable
	Typical cost per pound cleaned[4]	$0.63-$1.94 avg. $1.02	$0.57-$1.32 avg. $1.10	$1.40	$0.73-$1.02 avg. $0.88	Unavailable	$1.14	$1.08-$2.33 avg. $1.71	Unavailable
Environmental	Persistence[5] (water, soil, sediment, air)	M (water), H (soil, sed, air)	L (water, soil, air), M (sed)	NA	L (water, soil, air), M (sed)	L (water, soil, air), M (sed)	L (water, soil, air), M (sed)	L (water), M (soil), H (sed, air)	L (water, soil), M (sed), H (air)
	Bioaccumulation[6]	Low	Low	NA	Moderate	Low	Low	Moderate	Low
	Aquatic Toxicity[7]	Moderate	Low to Moderate[8]	Low	High	Moderate[9]	Low	High	High
Human Health	Recommended Exposure limits[10]	25 ppm	NE	5000 ppm	100 ppm[11]	NE	NE	10 ppm[12]	10 ppm
	Central Nervous System Effects	Yes	No[13]	No[14]	Yes	No data available	Yes	Some evidence	Yes
	Carcinogenicity	IARC Probable human carcinogen	Not classified by IARC	Not classified by IARC	Not classified by IARC	Not classified by IARC	Not classified by IARC	Some evidence	Clear evidence in animal studies by NTP
	Reproductive / Developmental Toxicity	Yes	Negligible[15]	No data available	No data available	No data available	No[16]	Studies indicate concern	Yes

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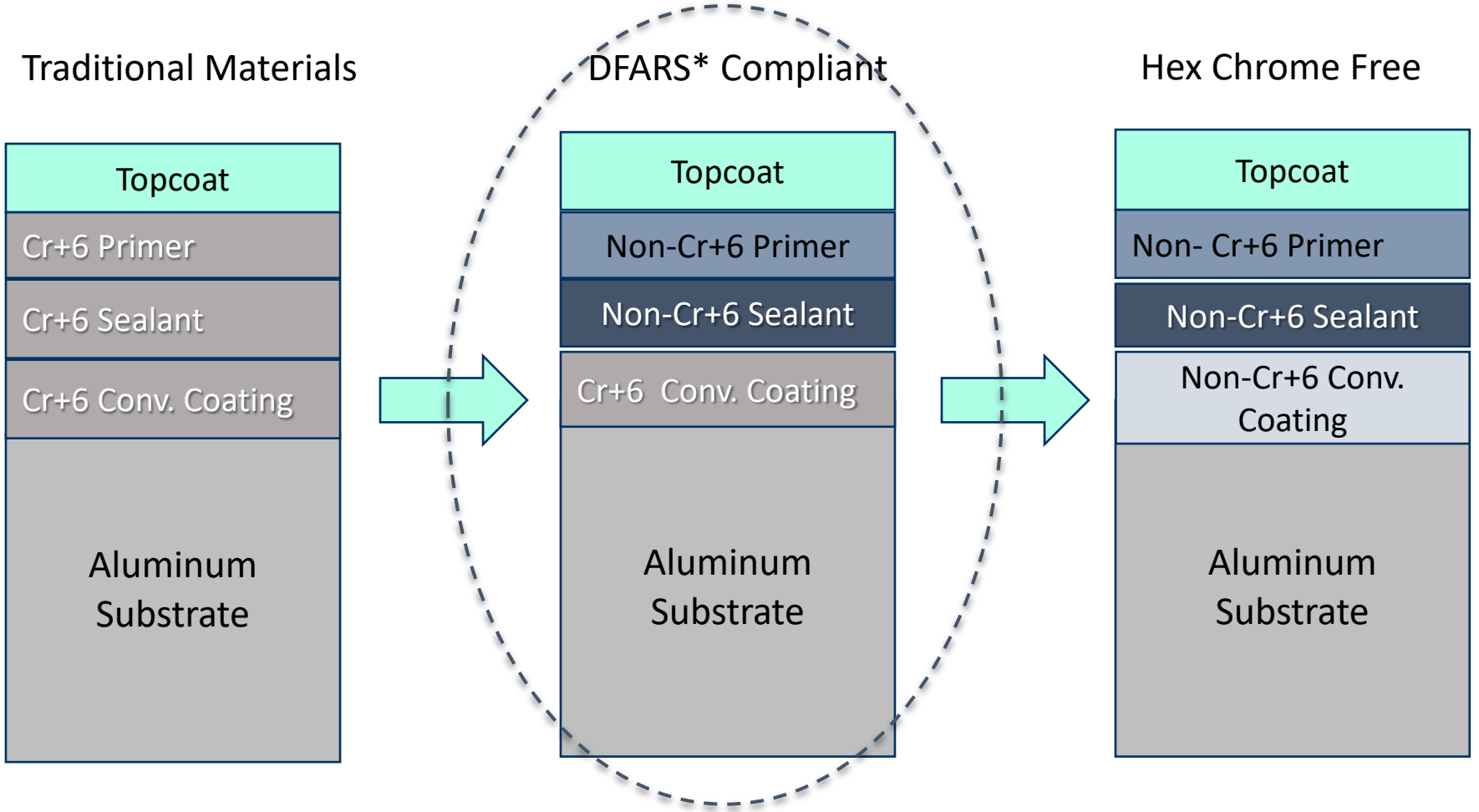
Reducing Use of Hexavalent Chromium

Aerospace/Defense Applications

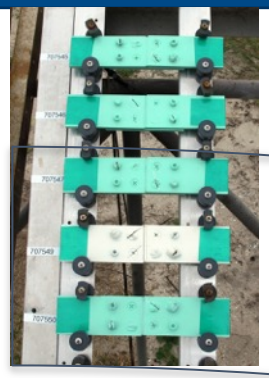


* Defense Federal Acquisition Regulation Supplement (May 2011)

Industry Collaborative Performance Testing Approach

Accelerated Corrosion Test, Inspection & Analysis

LOCKHEED MARTIN



Long-term Corrosion Test

NASA

Statistical Analysis & Documentation

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Test Vehicle Assembly*

Raytheon

Test Vehicle Preconditioning

NAVAIR
Naval Air Systems Command

Conversion Coating

METALAST INTERNATIONAL, INC.

NORTHROP GRUMMAN

Evaluating Relative Hazard of Alternatives

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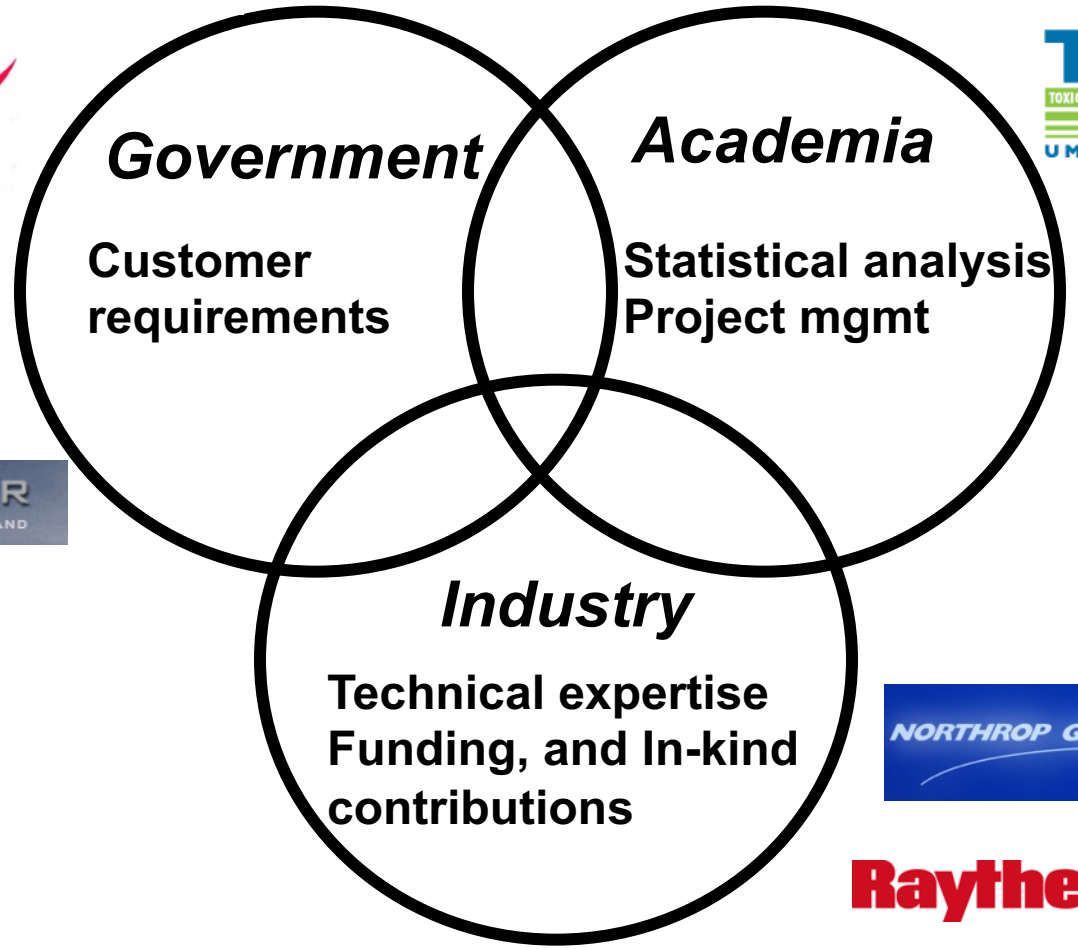
Hex Chrome Free Sealant Evaluation Team



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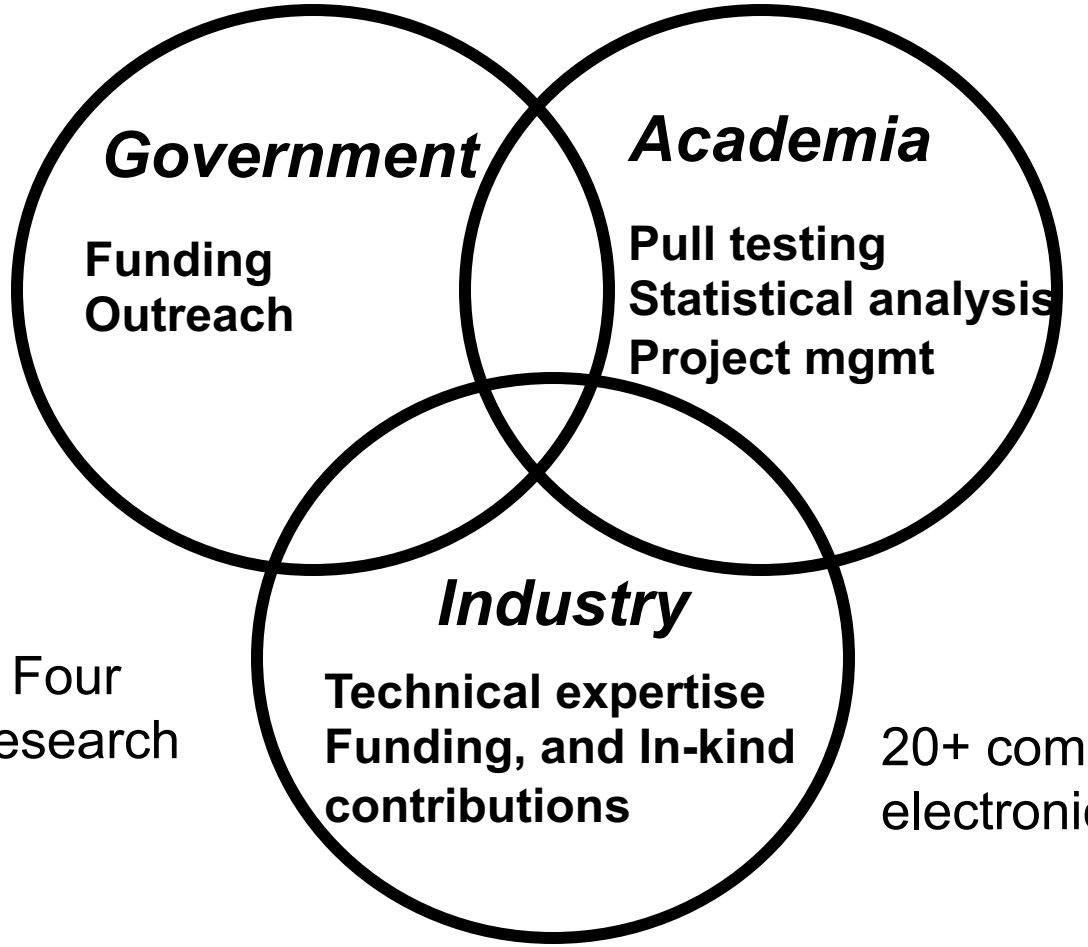
New England Lead-free Electronics Consortium

$1.5 million total in direct funding and in-kind contributions



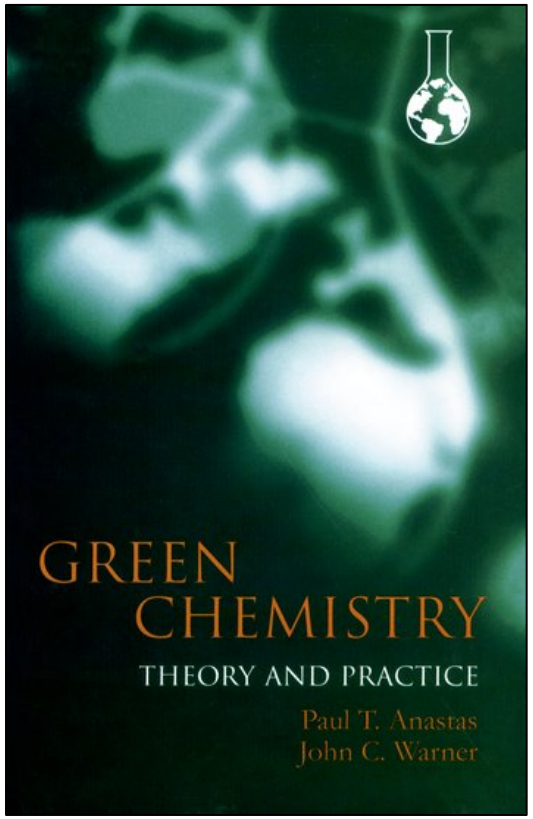
2001 – 2009 Four Phases of Research

20+ companies in the electronics industry

Sometimes new solutions need to be designed

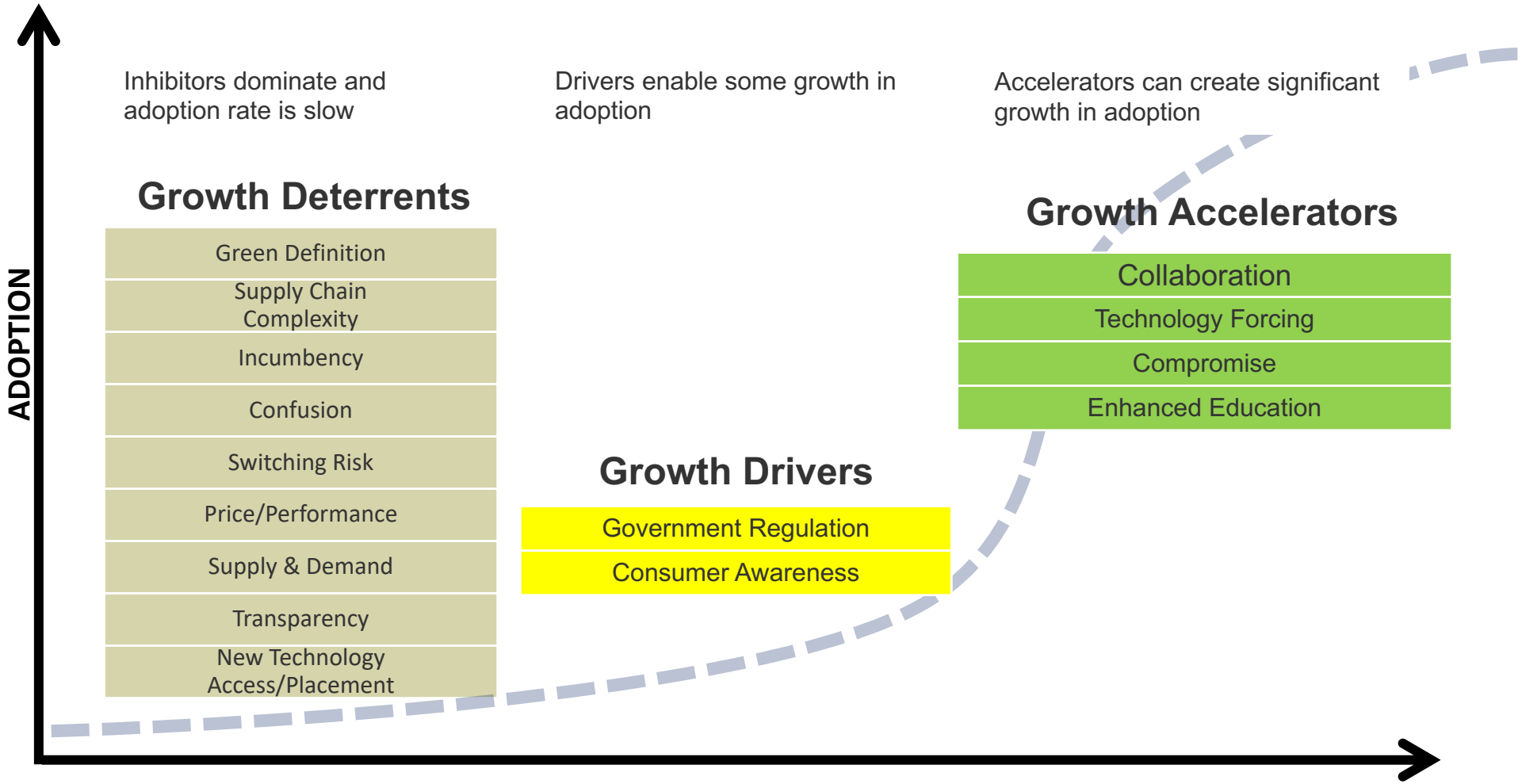
Green chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances.

Follows 12 Principles of molecular design



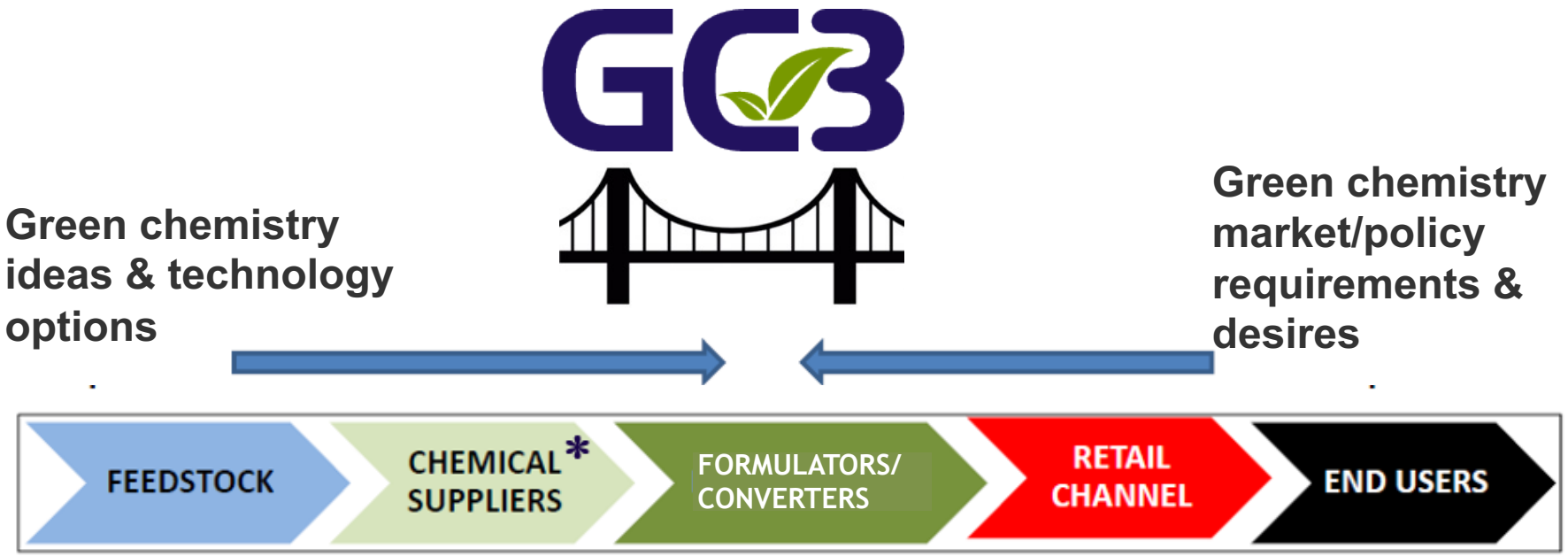
Paul Anastas and John Warner, ***Green Chemistry: Theory and Practice*** (1998)

Great idea but there are lots of challenges….



https://greenchemistryandcommerce.org/resources/gc3-publications

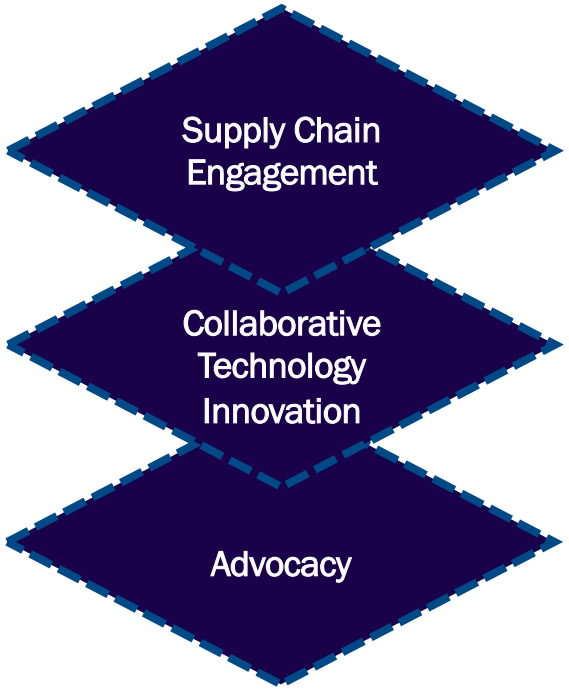
GC3: Bridging the Supply Chain to Accelerate Green Chemistry Innovation



* Established companies & startups

Accelerating the Commercialization of Green Chemistry: Major GC3 Platforms and Projects

Platforms



Projects

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Connecting to emerging global themes driving action on chemicals

https://www.un.org/sustainabledevelopment
https://www.unenvironment.org/explore-topics/chemicals-waste/what-we-do/policy-and-governance/global-chemicals-outlook
https://www.chemicalfootprint.org/
https://www.ellenmacarthurfoundation.org/

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What the future is likely to bring…

- Increased scrutiny of chemical problems - legacy
- Increased regulatory and market focus on avoiding chemicals of concern – including classes of chemicals
- Greater focus on end of life of materials (circularity) reuse/recovery and toxicity particularly in Europe – new regulatory policies
- Increasing regulatory scrutiny in Asia on chemicals
- When governments don't act, marketplace, including investors will…

Where alternatives assessment and informed substitution will be going

- Growth and greater standardization of tools and best practices
- Growth of community of practitioners
- Shift from informed substitution being a “compliance” activity to an innovation opportunity (and increased funding) – from problem space to solutions space
- Will lead to greater pre-competitive collaboration to solve problems and address cost, technical, transitional barriers

Lessons learned on driving safer chemistry

- A mix of regulatory and non-regulatory policy tools is needed to support the transition to safer chemicals including requirements to evaluate alternatives when restrictions are proposed
- Don’t get caught up in paralysis by analysis, keep alternatives assessment flexible and iterative and adaptable to decision-contexts and different users
- Focus on both assessment and adoption
- Responsibility to create, use, procure materials that are high performing but ALSO do not create unintended consequences through their lifecycles.
- The transition will take decades, but defense community plays a critical role in supporting it

Alternatives Assessment Resources

- **OECD Substitution and Alternatives Assessment Toolbox** – Tools and model alternatives assessments [http://www.oecdsaatoolbox.org]
- **OSHA Transitioning to Safer Chemicals** – Simple alternatives assessment process for small and medium sized companies with links to many tools [https://www.osha.gov/dsg/safer_chemicals]
- **Massachusetts Toxics Use Reduction Institute** – TURI reports, tools, library, assessments [www.turi.org]
- **Interstate Chemicals Clearinghouse** – Policy database, hazard assessment database [http://www.theic2.org]
- **Subsport** – Tools, assessments, frameworks and training materials [www.subsport.eu]
- **Clean Production Action** – GreenScreen, Chemical Footprint and alternatives assessment resources – [www.cleanproduction.org]
- **Chemical Commons** – Searchable chemical hazard data [https://commons.healthymaterials.net]

Thank You!

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For more information, visit:

Green Chemistry & Commerce Council (GC3) | www.greenchemistryandcommerce.org

Association for the Advancement of Alternatives Assessment (A4) | www.saferalternatives.org

Toxics Use Reduction Institute (TURI) | www.turi.org

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