

Advancing green chemistry and safer chemical alternatives

Challenges, Lessons Learned, and Opportunities

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Challenges of textile and apparel suppliers

- Chemically-intensive processes
- Limited upstream information from suppliers
- Multiple demands from different manufacturers
- Cost-containment pressures
- Limited technical resources

Three ways suppliers can reduce use and generation of toxic substances

- Toxics Use Reduction
 - How evaluate and modify manufacturing processes to reduce toxics and waste
 - Pollution prevention or cleaner production
- Alternatives Assessment
 - How to evaluate alternatives to chemicals of concern for a particular function
- Green Chemistry
 - How to design chemistries to be benign through their lifecycles

To move to safer chemistry, suppliers need to

1. Undertake materials accounting to understand chemicals throughput.
2. Undertake planning processes to understand why chemicals used and reduction opportunities.
3. Collaborate with other suppliers, brands, governments and academics in designing, evaluating, and applying safer chemicals

Toxics Use Reduction – an approach for suppliers to reduce use of toxic substances

- Passed into Massachusetts law in 1989
- Requires Planning and Reporting of materials throughput by applicable facilities
- Focus on understanding how and why chemicals are used and planning to reduce use and emissions.
- Also known as Cleaner Production

What is Toxics Use Reduction?

Toxics Use Reduction Act Definition:

In-plant changes in production processes or raw materials that reduce, avoid, or eliminate the use of toxic or hazardous substances or generation of hazardous byproducts per unit of product, so as to reduce risks to the health of workers, consumers, or the environment, with out shifting risks between workers, consumers, or the environment. TUR shall be achieved through any of the six defined techniques.

The Six TUR Techniques



1. Input substitution
2. Product reformulation or redesign
3. Equipment or technology modernizations
4. Process or procedure modifications
5. Improvements in housekeeping, maintenance, training, or inventory control
6. In-process recycling

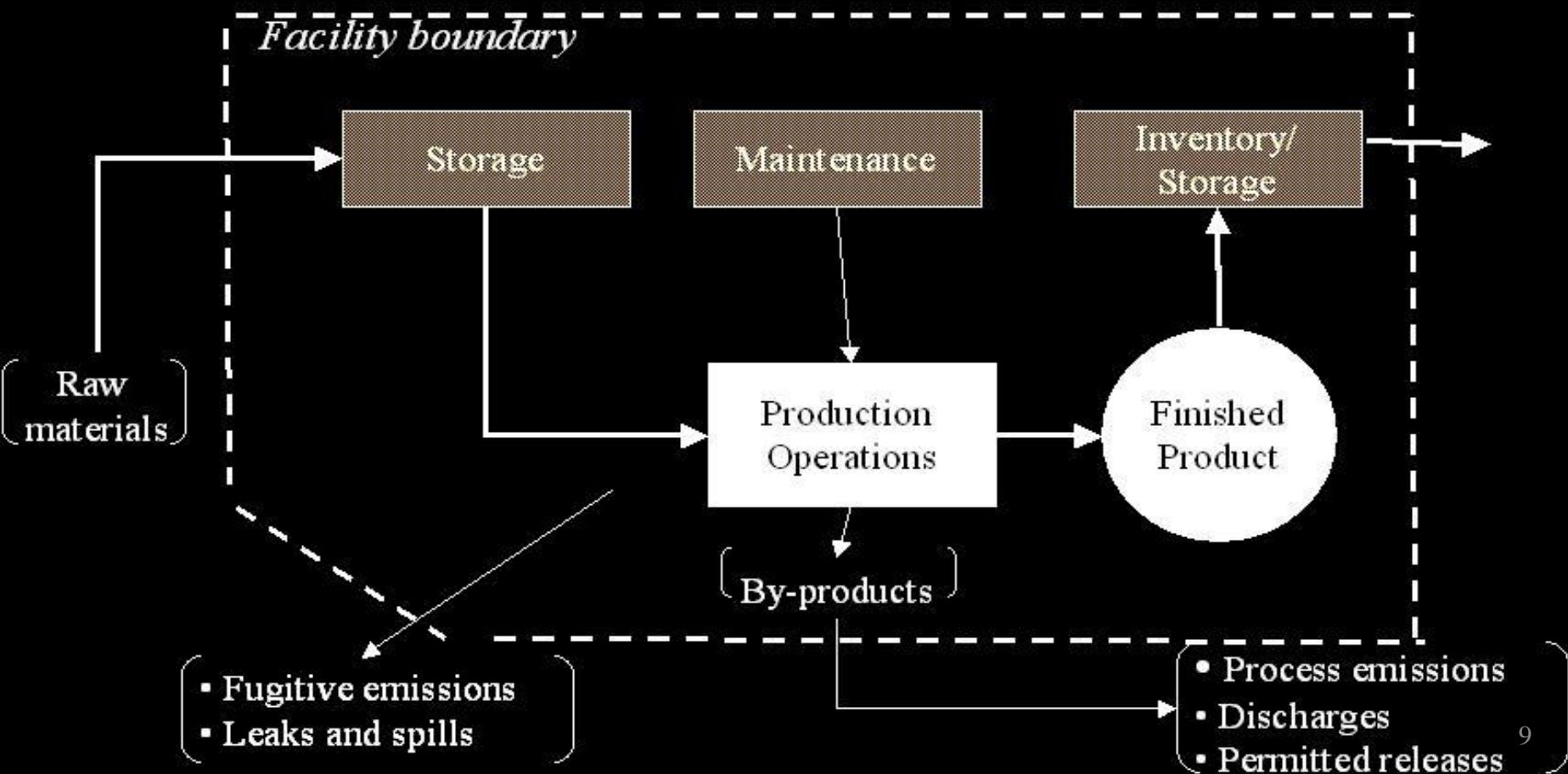
Two parts of Toxics Use Reduction: Materials accounting and planning

- Materials accounting – chemical throughput
 - You can't manage what you can't measure
- Planning:
 - Understanding how and why a chemical is being used and what alternatives exist
 - Process Characterization
 - Options generation/screening (EHS screening, prioritization of options)
 - Technical/financial analysis
 - Implementation

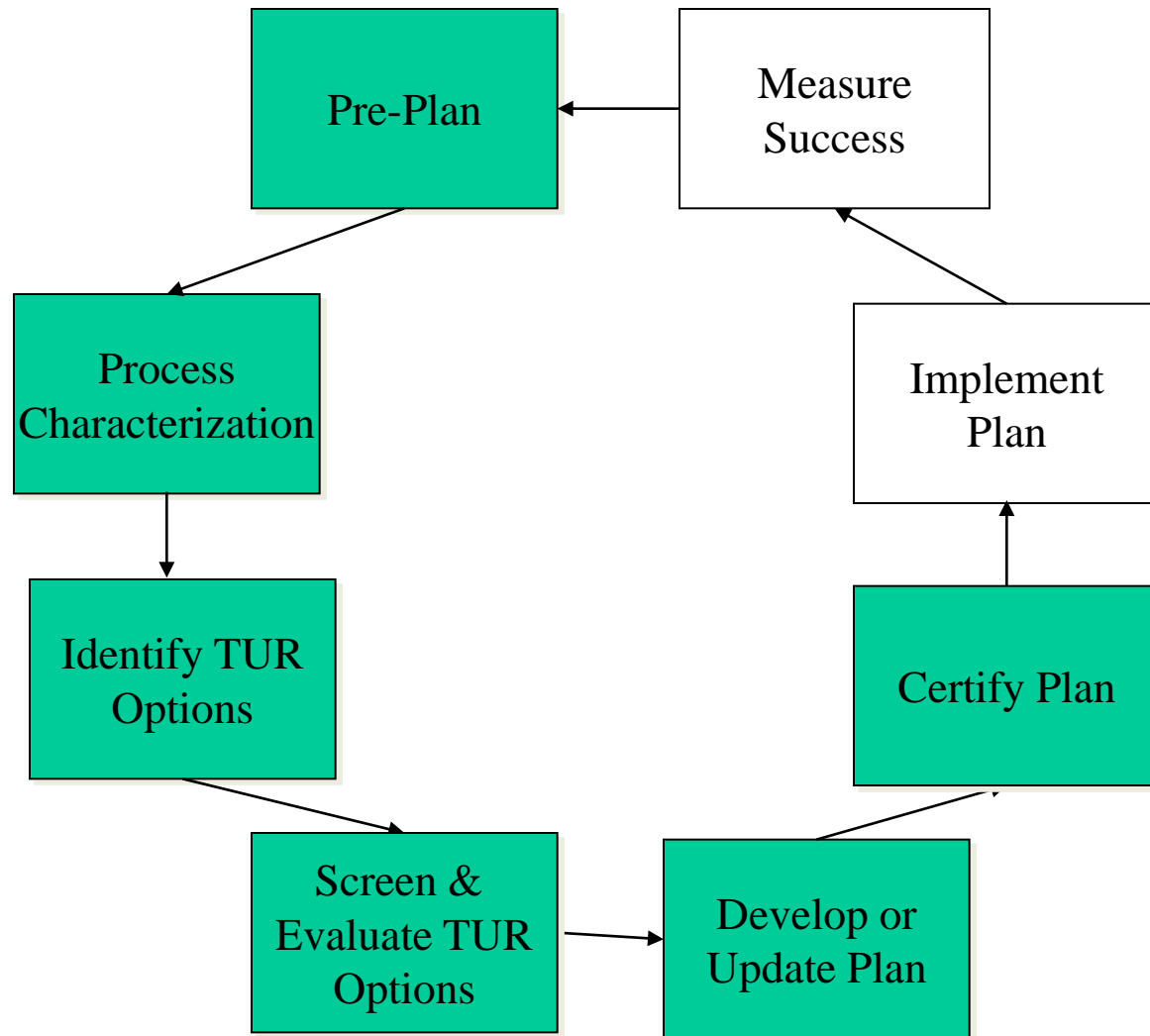


Process Mapping

P2 Flow Diagram



The TUR Planning Approach



 Denotes required elements of TURA program

Resources on Toxics Use Reduction/ Cleaner Production

- Massachusetts Toxics Use Reduction Institute – www.turi.org (reports, training materials)
- UNIDO Cleaner Production Program - <http://www.unido.org/index.php?id=o5133> (regional cleaner production centers, technical support, research)
- US EPA Pollution Prevention Division - <http://www.epa.gov/p2/> (research, resources)
- UNEP Cleaner Production Initiative - <http://www.unep.fr/scp/cp/> (includes Asia Sustainable Product Design project)

From Toxics Use Reduction to Safer Alternative Chemicals

- Toxics Use Reduction focus on in-plant changes NOT chemicals entering firm or in products
- Concerns about chemicals in product and regrettable substitutions
- Safer chemicals focus - consideration of whole lifecycle of a chemical/material.
- Requires supply chain collaboration – data sharing, information
- Also known as Informed Substitution

Alternatives Assessment – Defining the Process

- *Definition: A process for identifying and comparing potential chemical and non-chemical alternatives that could replace chemicals of concern on the basis of their hazards, performance, and economic viability*
- Goals:
 - Reduce hazards
 - Avoid regrettable substitutions
 - Support innovation in safer products
- Finding a safer alternative and ensuring adoption the use of it are not the same thing

Focus of Alternatives Assessment

- Alternatives assessment - step by step, continuous improvement process
 - Focus on function of chemical of concern
 - Focus on hazard reduction
 - Considers the “necessariness” of a chemical
- Includes: Drop in chemicals; Changes in production processes; changes in product design; Changes in how functions are performed; Non-chemical solutions

The Process of Assessing Alternatives – similar to toxics use reduction



www.ic2saferalternatives.org

Alternatives Comparison

- **EHS**
 - Safer from a human and ecological health perspective?
 - Increased hazards either upstream or downstream?
- **Technical**
 - Available?
 - Compatible with the existing technology or are changes needed
 - Product quality affected?
- **Economic**
 - Costs associated with continued use of the chemical?
 - Benefits/cost reductions come from using the alternative?

Comparative Chemicals Hazard Assessment – Part of Alternatives Assessment

- Comparative chemical hazard assessment tools:
 - German Column Model
 - Swedish Prio
 - US EPA's DFE Chemical Hazard Assessment Framework
 - Clean Production Action's Green Screen
 - <http://www.sustainableproduction.org/downloads/Methods-ToolsforChemHazardAss5-2011.pdf>
(compendium of tools for chemical hazard assessment)

Resources on alternatives assessment

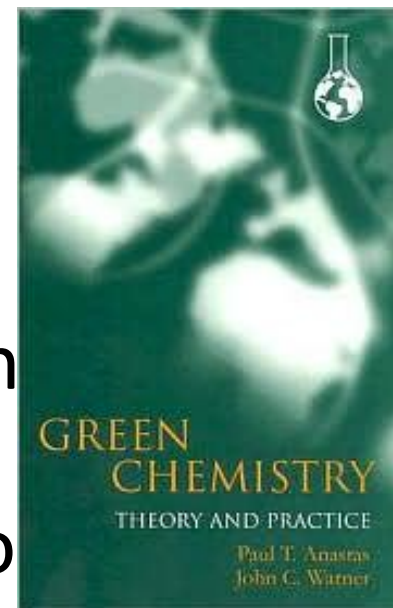
- Subsport Project – www.subsport.eu – database of case studies, evaluations, resources
- US EPA Design for Environment Program – www.epa.gov/dfe - research, methods
- Massachusetts Toxics Use Reduction Institute – www.turi.org research, training, resources
- Green Chemistry and Commerce Council – www.greenchemistryandcommerce.org – case examples, research, resources
- Clean Production Action – www.cleanproduction.org – NGO focused on advancing safer chemicals
- International Chemicals Secretariat – www.chemsec.org – developed SIN list of chemicals to avoid

From Safer Alternatives to Green Chemistry

- Technically feasible, cost effective alternatives may not exist
- New research to develop safer chemicals needed.
- Need for designers, chemists and materials engineers to incorporate understanding of safer design into chemical and material design stage

Green Chemistry

Green Chemistry is sustainability in chemistry



Definition:

“Green chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products.”

Twelve Principles of Green Chemistry

- Prevent waste (unconverted feedstock, spent reaction fluids)
- Maximize the incorporation of all process materials into the finished product
- Use and generate substances that possess little or no toxicity
- Preserve efficacy of function, while reducing toxicity
- Minimize auxiliary substances (e.g. solvents, separating agents)
- Minimize energy inputs (process at ambient temperatures and pressures)
- Prefer renewable materials over non-renewable materials
- Avoid unnecessary derivations (e.g. blocking groups, protection/de-protection steps)
- Prefer catalytic reagents over stoichiometric reagents
- Design products for natural, post-use decomposition
- Use in-process monitoring and control to prevent formation of hazardous substances
- Select substances and processes so as to minimize the potential for accidents

Green Chemistry Definition

- Focus on “hazard reduction” in design
- Comprehensive universe—Consider all stages of the life cycle of a chemical.
- Relevant to chemists—avoids issues of exposure and risk

Sustainable Chemistry

OECD Definition

“Sustainable chemistry is the design, manufacture and use of efficient, effective, safe and more environmentally benign chemical products and processes.”

- Organization for Economic Cooperation and Development, Brochure

Green Engineering

“Green engineering is the design, commercialization, and use of processes and products, which are feasible and economical while minimizing 1) generation of pollution at the source and 2) risk to human health and the environment.”

- U.S. Environmental Protection Agency, 2005

Green Chemistry Around the Globe

- Green Chemistry initiatives in 23 countries
- OECD Sustainable Chemistry Program –
(http://www.oecd.org/document/6/0,3343,en_2649_34375_1909638_1_1_1_1,00.html)

Asia

- India – Ministry of Science and Technology - 2003 - green chemistry program with conferences, scholarships, research funding, and industry collaboration.
- China – Green Chemistry Institute in Beijing
- Japan – Green and Sustainable Chemistry Network
 - Representatives from industry, government and academia
 - Promotion of R&D on green chemistry
 - Formation of Asia-Oceania network for green chemistry.

Europe

- England
 - York University Center of Excellence in Green Chemistry
 - Green Chemistry Network of the Royal Society of Chemistry
 - Crystal Faraday Partnership on green chemistry
- Germany
 - Environmental Protection Agency Sustainable Chemistry Initiative.
 - <http://www.umweltdaten.de/publikationen/fpdf-l/4169.pdf>

United States

- Presidential Green Chemistry Awards - U.S. EPA Green Chemistry Program
- ACS Green Chemistry and Engineering Conference and Green Chemistry Institute
- Three state green chemistry and economic development initiatives – Oregon, Michigan, Washington
- Education networks of professors for education, training and research.

Other countries

- Australia: Green Chemistry Center at the University of Monash
<http://www.chem.monash.edu.au/green-chem/>
- Canada
 - Green Centre Canada at Queens University – focus on commercialization -
 - <http://www.greencentrecanada.com/>

Green Chemistry Resources

- [University of Oregon Green Chemistry education resources - ttp://greenchem.uoregon.edu/gems.html](http://greenchem.uoregon.edu/gems.html)
- [Beyond Benign Foundation \(resources on green chemistry education\) - www.beyondbenign.org](http://www.beyondbenign.org)
- Green and Sustainable Chemistry Network Japan - <http://www.gscn.net/indexE.html>
- UK Green Chemistry Network – [www. Greenchemistrynetwork.org](http://www.Greenchemistrynetwork.org)
- Industrial Green Chemistry India - <http://www.industrialgreenchem.com/> (annual conference on green chemistry in Asia)
- American Chemical Society Green Chemistry Institute: portal.acs.org/portal/PublicWebSite/greenchemistry/index.htm

Barriers to safer chemicals at numerous levels

- Data
 - Lack of data on chemical toxicity, uses, product ingredients
 - Protection of confidential business information
 - Lack of standardized data reporting formats
 - Lack of good supply chain information flows
 - How is safer, green defined?

More barriers

- Implementation
 - Technical barriers that can compromise performance
 - Lack of cost-effective or viable alternatives
 - Lack of good incentives/disincentives
- Educational
 - Chemists not trained in toxicology
 - Designers not taught about environment and health

More barriers

- Institutional
 - Cost, performance first over health and environment
 - Technology lock-in
 - Lack of research funds for safer materials
 - Lack of technical or science capacity in many firms
 - Costs of more dangerous chemicals and products not internalized

Lessons Learned – Information Needs

- Good process/facility/supply chain level materials accounting information
 - Materials not efficiently managed
 - Identifies areas of high toxics use and efficiency opportunities
 - Critical to centralize materials data collection
 - Enhances understanding of supply chain
- Good metrics to measure progress
- Good information on alternatives to problem substances

Approaches to knowing what chemicals are in products

- Chemical content vs. toxicity data
- Supplier declarations for presence/lack of chemicals of concern
- Materials declarations
 - VPiP form
- Databases – such as
 - International Material Data System
 - Green Weracs -
<http://www.theweracs.com/products-and-services/greenweracs>
 - Actio -
<http://www.actio.net/default/index.cfm/products/>

Lessons Learned – Planning Needs

- Planning to reduce/eliminate problem chemical use through efficiency and substitution measures
- Focus on function of chemical
- Engage wide range of actors in firm and supply chain
- Considers whole process/facility hazards – continuous improvement approach
- Chemical substitution means process change
 - Consideration of product quality/economics
 - Consideration of health and safety trade-offs

Lessons Learned – Green Chemistry and Safer Alternatives

- Many tools to evaluate safer chemicals as well as case studies of alternatives
- Focus on function of chemical and whether it can be replaced through chemical or non-chemical means
- Think about upstream and downstream trade offs in EHS, product quality
- Focus on chemicals AND materials

Lessons Learned - Innovation

- Innovation requires both willingness AND capacity
- Technical support is critical for industry innovation
 - Demonstration projects/sites
 - Networking of firms
 - Research support
 - Technical assistance to firms

Lessons learned - Collaboration

- Given supply chain complexity - collaboration of chemical suppliers, manufacturers, retailers is critical.
- Collaboration with academics and government agencies to support research and application.
- Demonstration projects and supply chain dialogs - opportunities to share resources and demonstrate successes.

What should suppliers do

- Establish toxics use reduction planning programs
 - Do chemical/materials accounting
 - Develop standardized means to request information from suppliers
 - Undertake toxics reduction planning to evaluate process and product alternatives.
- Prioritize and evaluate alternatives to chemicals of concern
- When no safer alternatives, work with university researchers on green chemistry alternatives.

What should suppliers do

- Identify resources to assist in evaluating and implementing safer chemicals and production processes.
- Establish and join technical support and partnership networks
 - Work in collaboration with brands and suppliers to identify problem chemicals and safer chemicals
 - Create partnerships to test alternatives – EHS and performance – and demonstrate
 - Work with academic and government researchers to establish technical support networks.
- Support training and education in safer chemistry