GreenScreen® for Safer Chemicals:
Applications and New Developments

BizNGO Webinar

Sept 11, 2013 at noon Eastern

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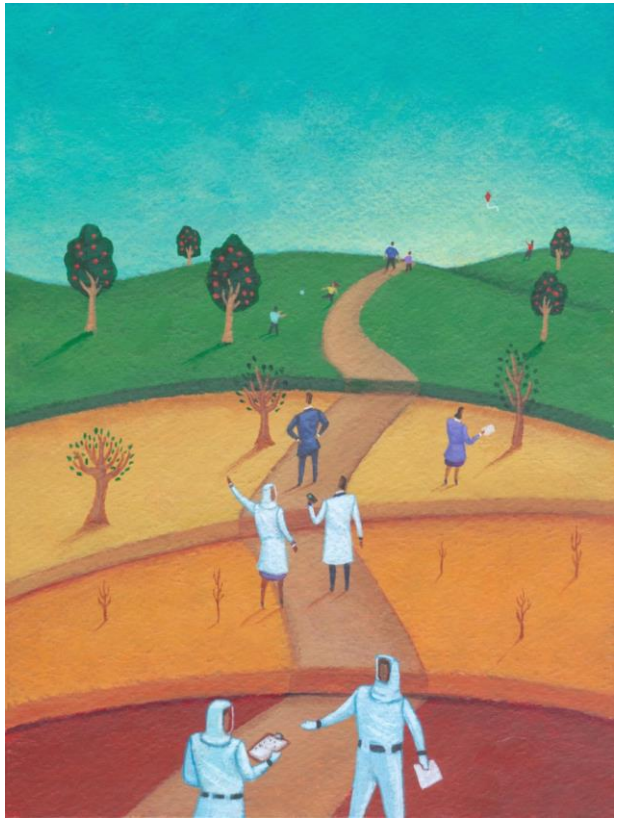
Consulting Co-Director Clean Production Action

What is the GreenScreen®?

- A method for comparative Chemical Hazard Assessment (CHA) developed by Clean Production Action (CPA)
- Builds on the USEPA Design for Environment (DfE) approach and other national and international precedents (OECD, GHS)
- Freely and publicly accessible, transparent and peer reviewed

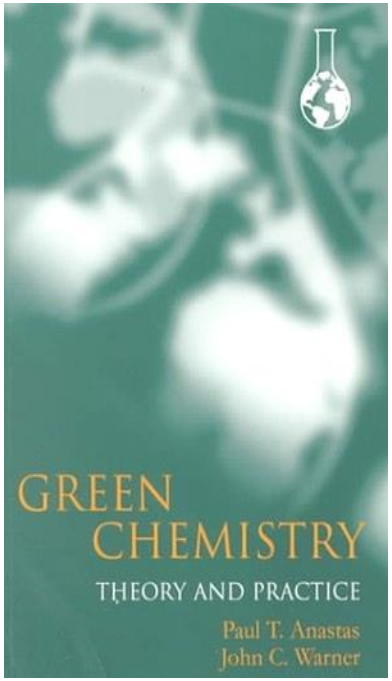


All supporting resources at: http://www.cleanproduction.org/Greenscreen.v1-2.php

Key Concept to Formulating: Reduce Risk by Reducing Inherent Hazard

Risk = *f*(Hazard, Exposure)

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



#3 Less hazardous chemical syntheses

#4 Design safer chemicals and products

#5 Use safer solvents and auxiliaries

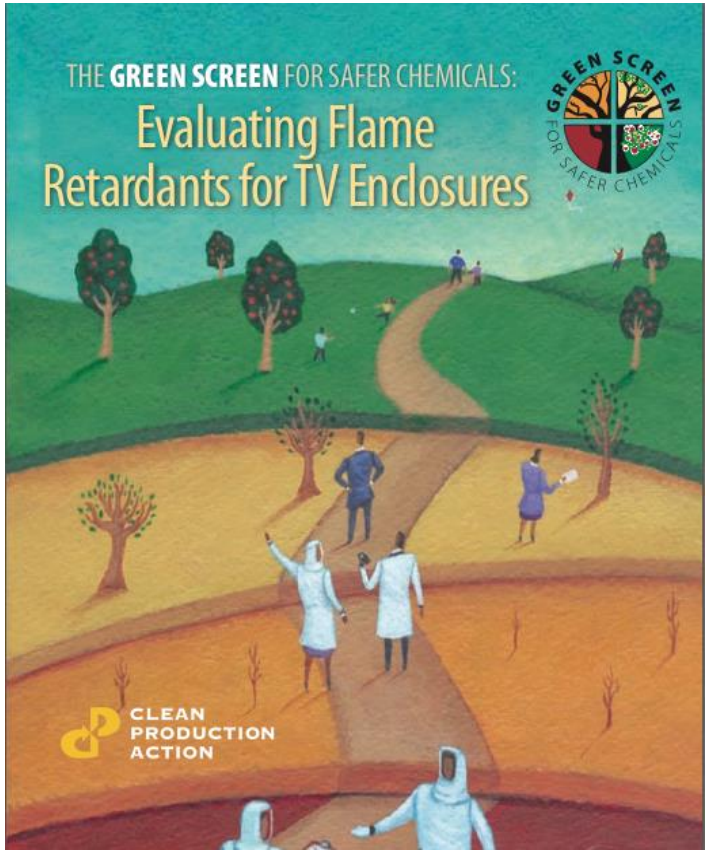
#10 Design chemicals and products to degrade after use

#12 Minimize the potential for accidents

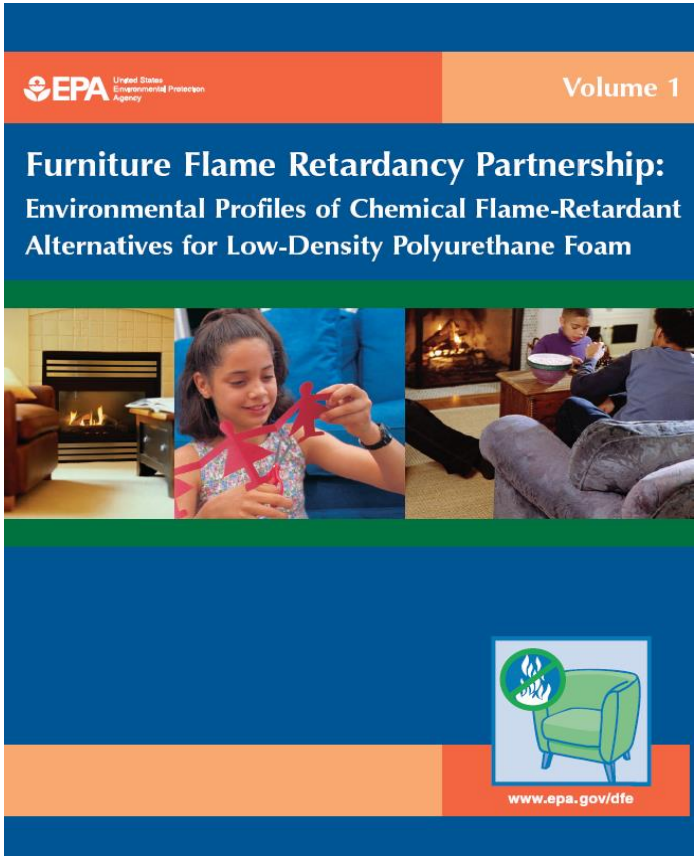
Five of the 12 Principles of Green Chemistry are focused on Hazard Reduction

Origins of the GreenScreen™

State governments seek to identify safer, functional alternatives



USEPA DFE chemical alternatives assessment partnerships



Builds on the USEPA Design for the Environment Approach: Hallmark of CHA

But how do I know which one is better?

USEPA DfE cannot offer scoring-

GreenScreen provides decision logic

Table 4-1 Screening Level Toxicology and Exposure Summary

L = Low hazard concern
M[1] = Moderate hazard concern
H = High hazard concern
L, *M*[1], or *H* = Endpoint assigned using estimated values and professional judgment (Structure Activity Relationships)

N = No
Y = Yes
P = Yes for pure chemical

*Ongoing studies may result in a change in this endpoint
▲Persistent degradation products expected[2]

Company	Chemical`	% in Formulation[3]	Human Health Effects							Ecotoxicity		Environmental		Potential Routes of Exposure						
														Worker			General Population			
			Cancer Hazard	Skin Sensitizer	Reproductive	Developmental	Neurological	Systemic	Genotoxicity	Acute	Chronic	Persistence	Bioaccumulation	Inhalation	Dermal	Ingestion	Inhalation	Dermal	Ingestion	Aquatic
Albemarle	ANTIBLAZE 180 and ANTIBLAZE 195																			
	Tris(1,3-dichloro-2-propyl)Phosphate CAS # 13674-87-8	95%	M	L	M	M	L	M	M	M	M	M	*L*	N	Y	Y	N	Y	Y	Y
Albemarle	ANTIBLAZE 182 and ANTIBLAZE 205																			
	Proprietary A Chloroalkyl phosphate (1)		M	L	M	M	L	M	M	M	M	M	*L*	N	Y	Y	N	Y	Y	Y
	Proprietary B Aryl phosphate		*L*	*L*	M*	M*	M	M*	*L*	H	*H*	*L*	*M*	N	Y	Y	N	Y	N	N
	Triphenyl Phosphate CAS # 115-86-6		*L*	L	L	L	L	M	L	H	*H*	L	L	Y	Y	Y	Y	Y	Y	Y
Albemarle	ANTIBLAZE V500																			
	Proprietary C Chloroalkyl phosphate (2)		*M*	M	*M**	*M**	L	M	L	M	M	M	*L*	N	Y	Y	N	Y	Y	Y
	Proprietary B Aryl phosphate		*L*	*L*	M*	M*	M	M*	*L*	H	*H*	*L*	*M*	N	Y	Y	N	Y	N	N
	Triphenyl Phosphate CAS # 115-86-6		*L*	L	L	L	L	M	L	H	*H*	L	L	Y	Y	Y	Y	Y	Y	Y
Albemarle	SAYTEX RX-8500																			
	Proprietary D Reactive brominated flame retardant		*L*	*M*	*L*	*L*	*M*	*M*	L	*M*	*M*	*L*▲	*L*	N	Y	Y	N	N	Y	Y
	Proprietary B Aryl phosphate		*L*	*L*	M*	M*	M	M*	*L*	H	*H*	*L*	*M*	N	Y	Y	N	Y	N	N
	Triphenyl Phosphate CAS # 115-86-6		*L*	L	L	L	L	M	L	H	*H*	L	L	Y	Y	Y	Y	Y	Y	Y

How to do a GreenScreen™ Assessment

1. **Assess and classify hazards**
2. Apply the Benchmarks
3. Make informed decisions

18 Hazard Endpoints

Human Health Group I	Human Health Group II and II*	Environmental Toxicity & Fate	Physical Hazards
Carcinogenicity	Acute Toxicity	Acute Aquatic Toxicity	Reactivity
Mutagenicity & Genotoxicity	Systemic Toxicity & Organ Effects	Chronic Aquatic Toxicity	Flammability
Reproductive Toxicity	Neurotoxicity	Other Ecotoxicity studies when available	
Developmental Toxicity	Skin Sensitization	Persistence	
	Respiratory Sensitization		
Endocrine Activity	Skin Irritation	Bioaccumulation	
	Eye Irritation		

GreenScreen™ Criteria

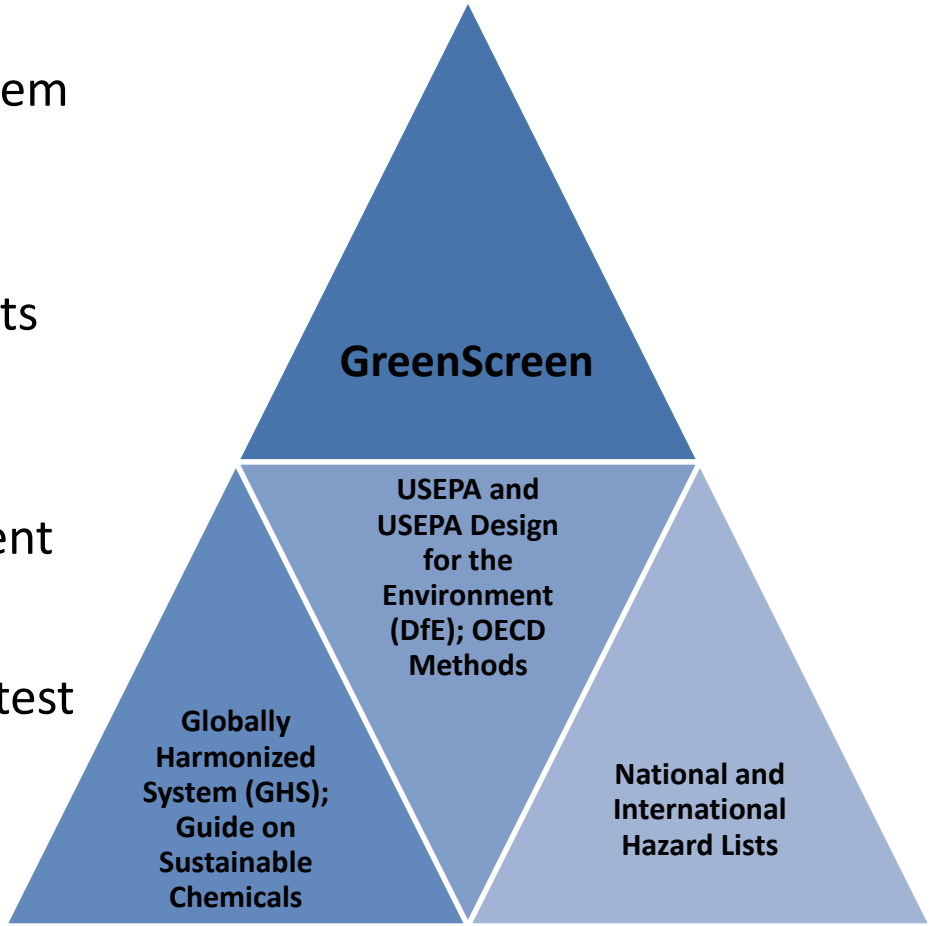
Example 1 - Carcinogenicity (C)

Information type	Information Source	High (H)	Moderate (M)	Low (L)
Data	GHS Category	1A (Known) or 1B (Presumed) for any route of exposure	2 (Suspected) for any route of exposure or limited or marginal evidence of carcinogenicity in animals	Adequate data available, and negative studies, no structural alerts, and GHS not classified.
A sample of A Lists	EPA-C (1986)	Group A, B1 or B2	Group C	Group E
	EPA-C (1996, 1999, 2005)	Known or Likely		Not Likely
	IARC	Group 1 or 2A	Group 2B	Group 4
	California Prop 65	Known to the state to cause cancer		

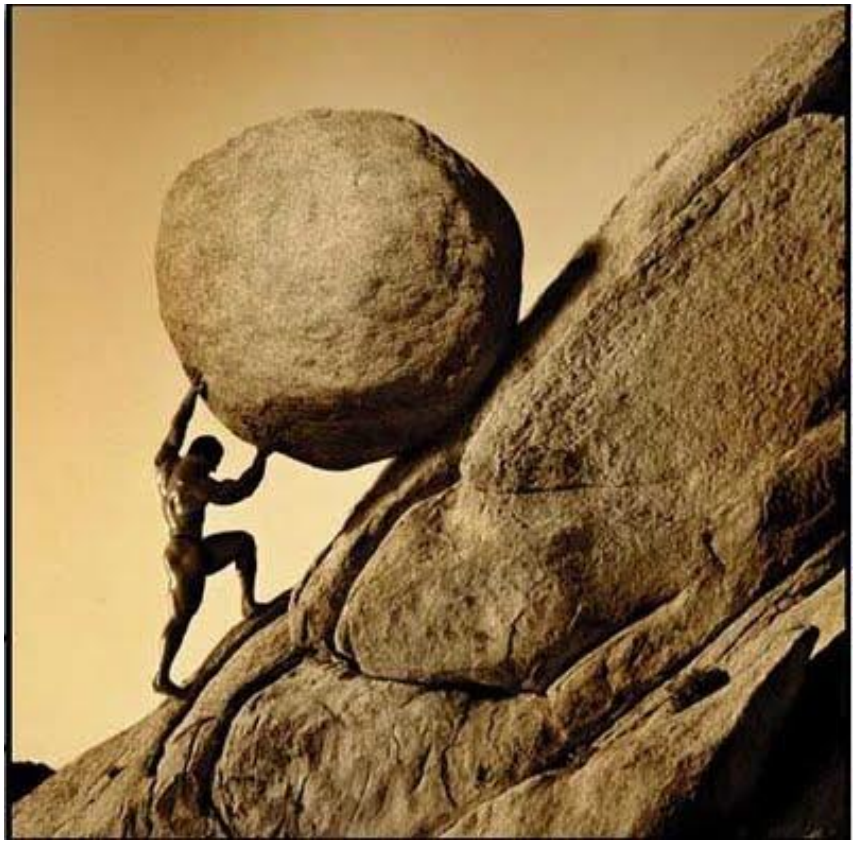
Where Do the Hazard Endpoints and Criteria Come From?

Source of GreenScreen Hazard Endpoints:

- GHS/CLP – Globally Harmonized System of Classification and Labeling of Chemicals (United Nations)
- OECD Screening Information Data Sets (SIDS) and test methods
- USEPA Design for the Environment Program (DfE) Alternatives Assessment Criteria for Hazard Evaluation
- USEPA New Chemicals Program and test methods
- Others; eg. Candian DSL



Assess & Classify Hazards



- Literature review
- Test Data
- Analogs/Surrogates
- Q/SAR Models
- Hazard Lists

Assess & Classify Hazards: Final Product -- Documented Findings & Conclusions

Mutagenicity/Genotoxicity (M) Score (H, M or L): M

Vinyl acetate was assigned a score of Moderate for mutagenicity based on classification as a GHS Category 2 germ cell mutagen, due to positive *in vitro*, and weakly positive *in vivo* assays.

- *In vitro* - Several Ames bacterial reverse mutation assays (GLP-compliance not reported; only one study was identified as following OECD 471 Guidelines) were identified utilizing *Salmonella typhimurium* tester strains TA 97, TA98, TA100, TA102, TA1530, TA1535 and TA1537 with and without metabolic activation (concentrations not reported). Vinyl acetate was determined to be negative for mutagenicity under all tested conditions (ESIS 2000).
- *In vitro* – Several cytogenetic assays (GLP-compliance and method not reported) were identified utilizing human lymphocytes and Chinese Hamster Ovary (CHO) cells with and without metabolic activation (concentrations not reported). Vinyl acetate (purity not reported) tested positive for clastogenicity in human lymphocytes and CHO cells under tested conditions (ESIS 2000).
- *In vitro* – A mouse lymphoma assay was conducted (GLP-compliance and method not reported) utilizing L5178Y cells without metabolic activation (concentration not reported). Vinyl acetate (purity not reported) was found to be positive for mutagenicity under the tested conditions (ESIS 2000).
- *In vitro* – A micronucleus assay (GLP-compliance not reported; high content cytotoxicity method developed by Litton Laboratories) was conducted utilizing human TK6 cells without metabolic activation at concentrations of 0, 0.001, 0.005, 0.01, 0.05, 0.25, 0.5, 1.0 and 2.0 mM of vinyl acetate (purity not reported). Increased incidences of micronucleated events occurred at concentrations of 0.5 to 2.0 mM of vinyl acetate in a dose-dependent manner

Populate Hazard Summary Table with Hazard Classification Levels

Green Screen Hazard Ratings																			
Group I Human					Group II and II* Human									Ecotox		Fate		Physical	
Carcinogenicity	Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity		Neurotoxicity		Skin Sensitization*	Respiratory Sensitization*	Skin Irritation	Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Persistence	Bioaccumulation	Reactivity	Flammability
						single	repeated *	single	repeated *	*	*								
L	L	L	M	M	L	L	L	vH	H	L	L	L	L	H	H	vL	L	M	L

Level of Concern:

- vH = very High
- H = High
- M = Moderate
- L = Low
- vL = very Low
- DG = Data Gap

Populate Hazard Summary Table … and with Levels of Confidence

Green Screen Hazard Ratings																			
Group I Human					Group II and II* Human									Ecotox		Fate		Physical	
Carcinogenicity	Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity		Neurotoxicity		Skin Sensitization*	Respiratory Sensitization*	Skin Irritation	Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Persistence	Bioaccumulation	Reactivity	Flammability
						single	repeated *	single	repeated *	*	*								
L	**L**	**L**	**M**	*M*	**L**	**L**	**L**	**vH**	*H*	**L**	**L**	**L**	**L**	**H**	**H**	**vL**	**L**	M	*L*

Level of Concern:

- vH = very High
- H = High
- M = Moderate
- L = Low
- vL = very Low
- DG = Data Gap

Level of Confidence:

- **Bold = High confidence**
- *Italics = Low confidence*

Optional Hazard Summary Table: Make Exposure Route Transparent

- Example of a GreenScreen™ that incorporates route of exposure in benchmark score: potassium permanganate ($KMnO_4$)

Figure 1: GreenScreen™ Hazard Ratings for Potassium Permanganate

Route of Exposure	Group I Human					Group II and II* Human								Ecotox		Fate		Physical	
	C	M	R	D	E	AT	ST		N		SnS*	SnR*	IrS	IrE	AA	CA	P	B	Rx	F
							single	repeated*	single	repeated*										
Inhalation	*L*		M	M		DG	DG	M	DG	H										
Oral	*L*	L	M	H	M	M	vH	M	DG	H	L	DG	vH	vH	vH	H	*L*	vL	H	*L*
Dermal	*L*		*L*	*M*		L	H	M	DG	DG										

Note: Hazard levels (Very High (vH), High (H), Moderate (M), Low (L), Very Low (vL)) in *italics* reflect estimated values and lower confidence. Hazard levels in **BOLD** font reflect values based on test data (See Guidance). Please see Appendix A for a glossary of hazard acronyms.

Thank you to Dr. Margaret Whittaker for use of this slide

Fumed Nano Silica (DRAFT only)

The scope of this GreenScreen is intentionally restricted to use of fumed silica as a flow agent in foods and powders.

Rating[3]: Nano fumed silica was assigned a Benchmark Score of 4 based on low bioavailability, and general lack of toxicity in animal studies and with human experience.

GreenScreen™ Hazard Ratings: Nano fumed silica																	
Group I Human					Group II and II* Human								Ecotox		Fate		Physical	
						ST		N										
C	M	R	D	E	AT	Single	Repeated*	Single	Repeated*	SnS*	SnR*	IrS	IrE	AA	CA	P	B	RX	F
L_o	L	L_o	L_o	L	L_o	L_o	L_o	L_o	L_o	L	L	L	L	L	*L*	vH	L	L	L
L_d		L_d	L_d		L_d	L_d	L_d	L_d	L_d										
L_i		L_i	L_i		Li	L_i	L_i	L_i	L_i										

Note: Hazard levels (Very High (vH), High (H), Moderate (M), Low (L), Very Low (vL)) in *italics* reflect estimated values and lower confidence. Hazard levels in **BOLD** font reflect values based on test data (See Guidance).

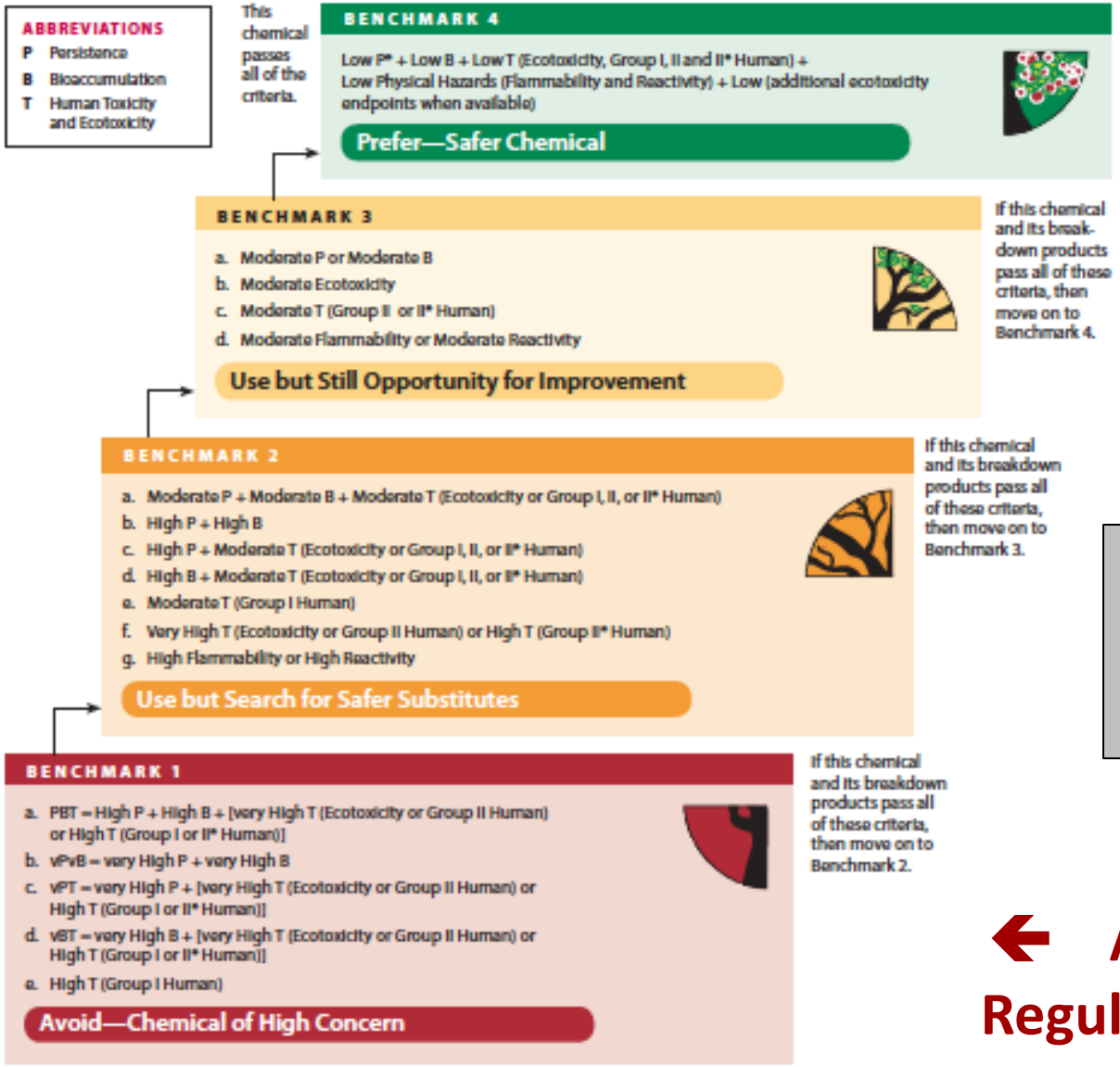
How to do a GreenScreen™ Assessment

1. Assess and classify hazards

2. Apply the Benchmarks

3. Make informed decisions

Step 2: Apply the Benchmarks to the Hazard Classifications

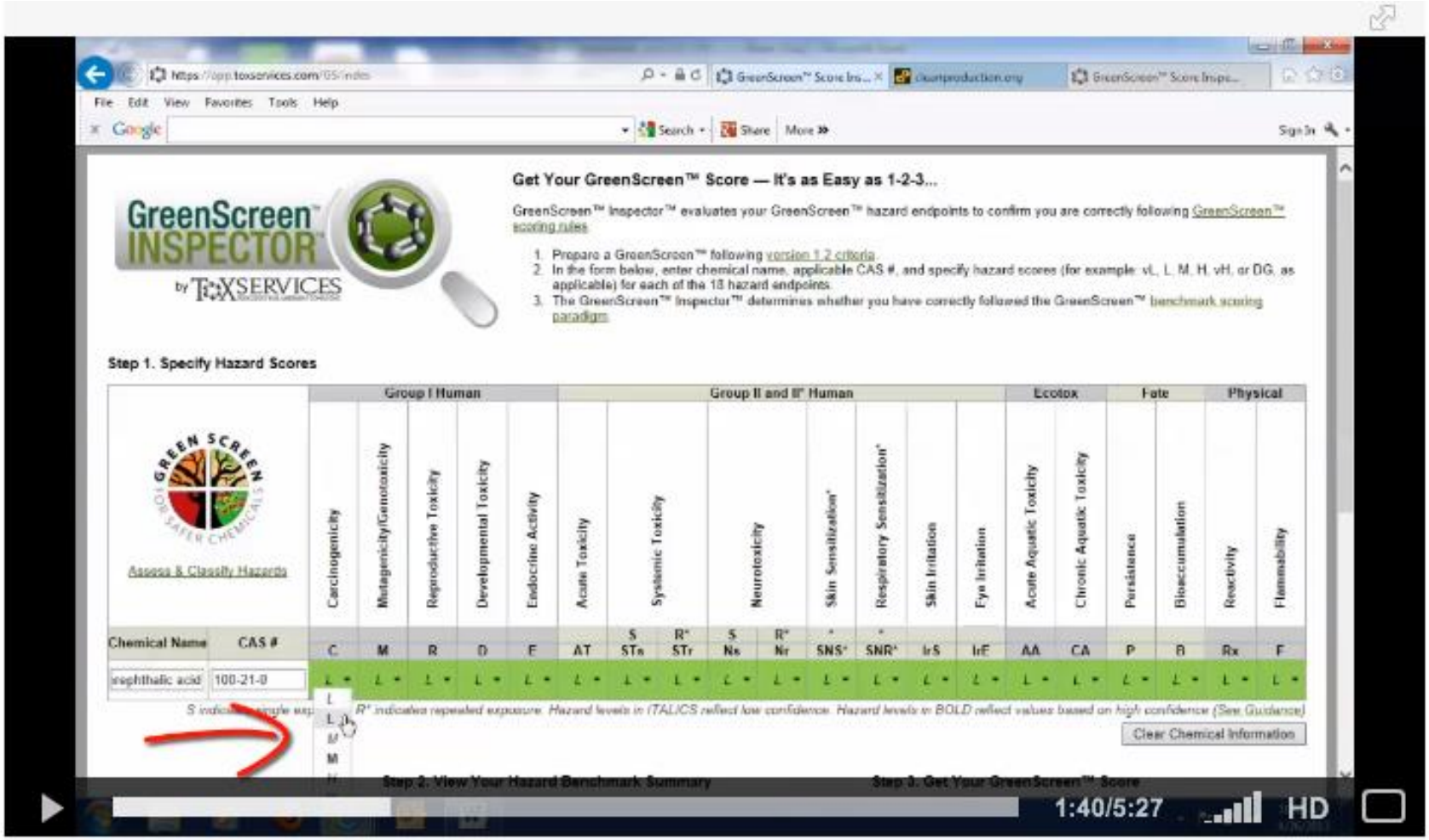


Benchmark U = Undetermined due to insufficient data

← **Aligned with Regulatory Drivers**

GreenScreen® Inspector™

at www.toxservices.com



How to do a GreenScreen Assessment

1. Assess and classify hazards

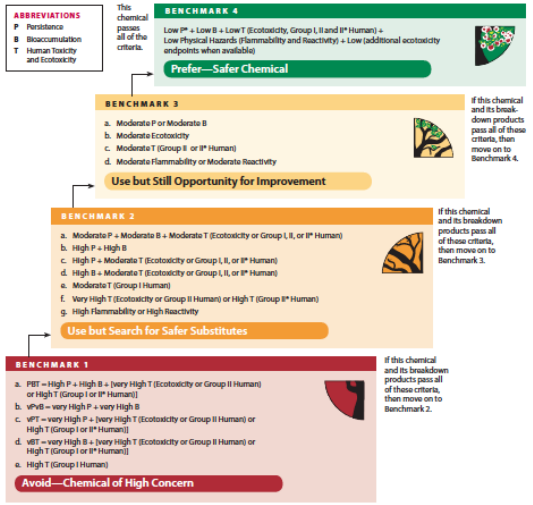
2. Apply the Benchmarks

3. **Make informed decisions**

Value of Benchmark Score

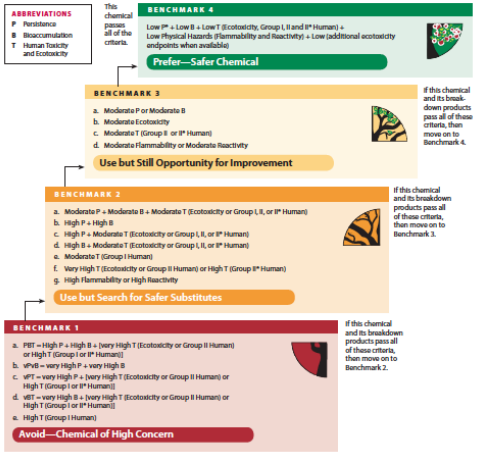
Results can be presented as a simple 1-4 score that supports taking action:

- BM1 – avoid/phase out
- BM2 – manage to use safely
- BM3 – getting there
- BM4 – inherently low hazard

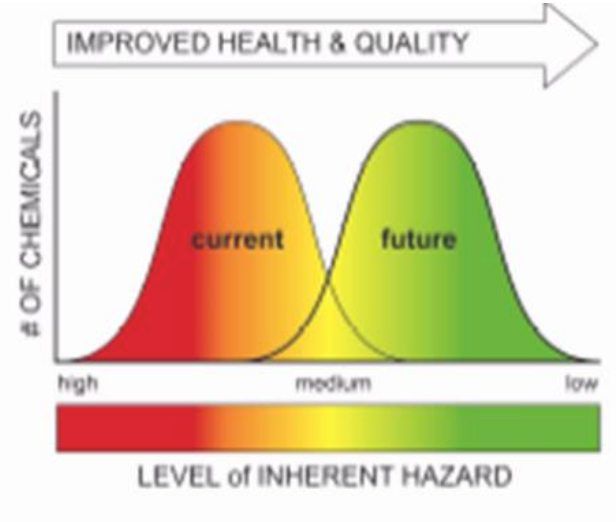


Value of Benchmark Score

- Scores can be used without <u>toxicology training</u>
- Drives wider adoption of preferred materials
  - Preferred materials/positive list
  - Guide new product development
  - Drives innovation of new materials

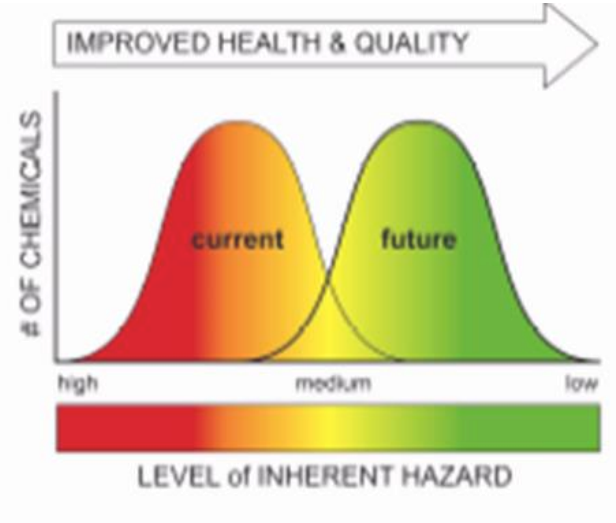


Applications for GreenScreen



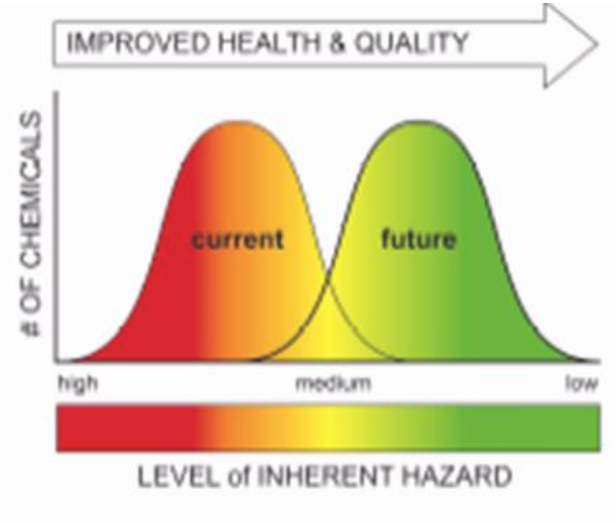
1. **Support State Alternatives Assessment Regulations**
   - Interstate Chemicals Clearinghouse
     - IC2 AA Guidance
     - Website/database of GS assessments
   - ME Safer Chemicals in Children's products; WA; CA DTSC….
2. ****Materials Procurement*** *- Identify chemicals of concern* ***and*** *safer alternatives*
   - *E.g. Hewlett Packard approved materials list; mandatory for HP suppliers provid*ing potential replacements

Applications for GreenScreen/CHA



3. **Product Development**
   - New formulations
     - E.g., Green Chemistry and Commerce Council consortium to evaluate alternative plasticizers for wire and cable applications
   - New chemicals
     - EU PINFA pilot to identify inherently lower hazard non-halogenated flame retardants
4. **Corporate Policies**
   - Manage chemical inventories
     - E.g. Staples corporate policy,
     - HP corporate policy
     - Nike corporate sustainability report

Applications for GreenScreen/CHA

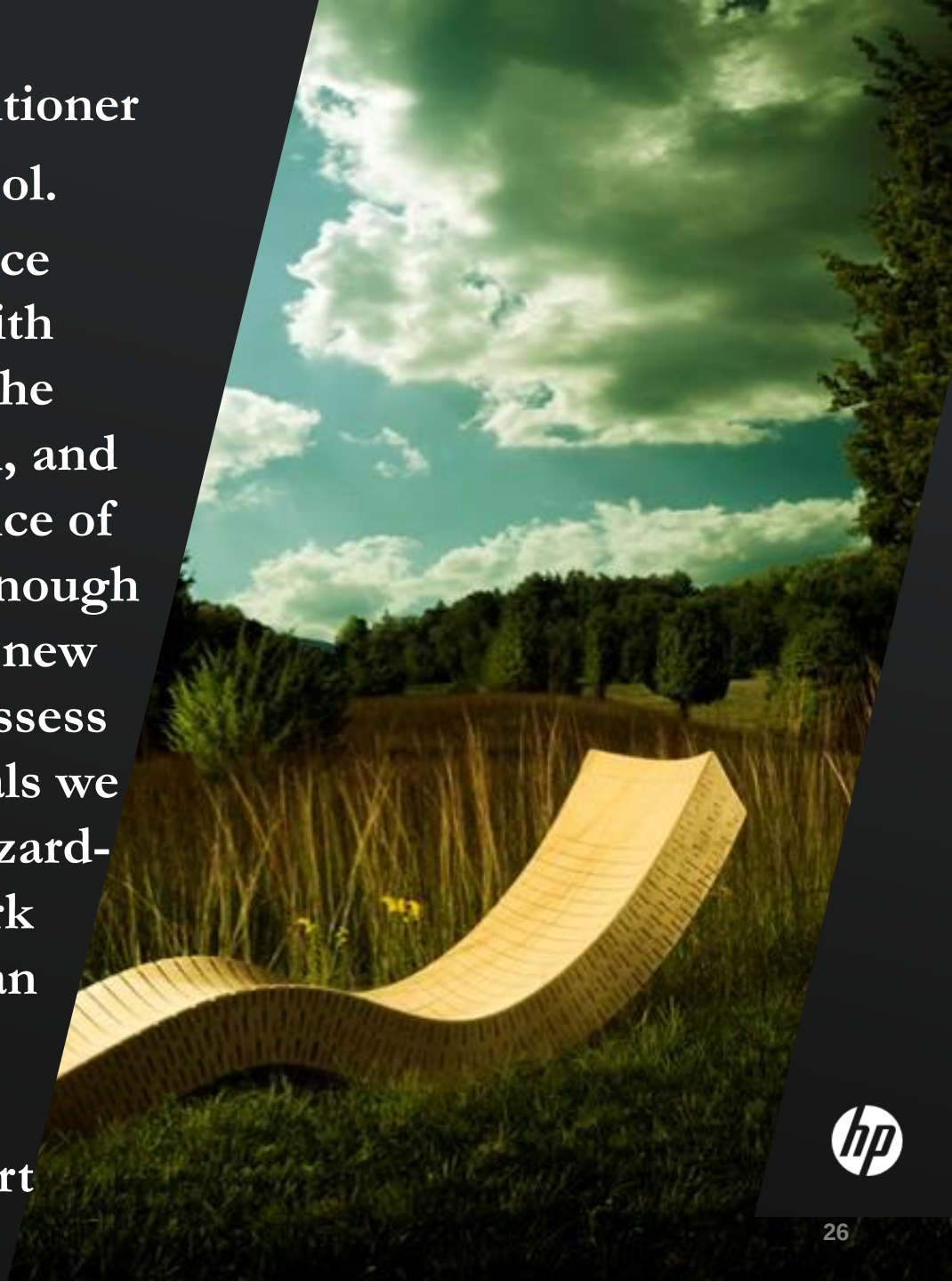


5. ***Standards, Scorecards and Ecolabels***
   - *USGBC LEED v4*
     - *Health Product Declaration*
   - *MOU with C2C Product Innovation Institute*
   - BizNGO Guide to Safer Chemicals

HP is the world's leading practitioner of the GreenScreen™ tool.

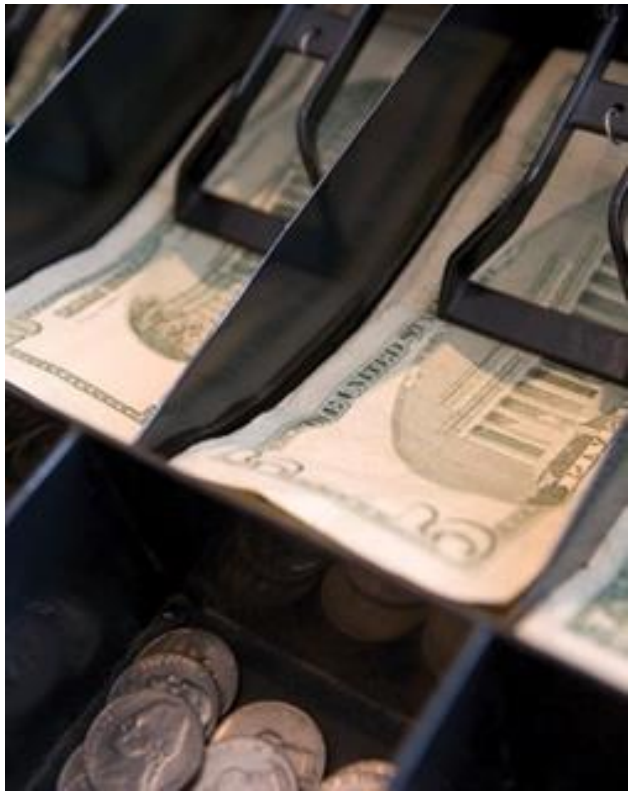
"HP has committed to replace restricted substances only with materials that are better for the environment and human health, and when there is sufficient assurance of required volumes and we have enough time to design and qualify the new material into the product. To assess alternative replacement materials we now use the GreenScreen, a hazard-based assessment framework developed by the NGO Clean Production Action."

HP's Global Citizens Report



Choosing Better Materials

- Replacing materials is expensive
  - Want to select alternatives that won't be restricted in the future
- Replacements should have lower environmental impact
  - Want to avoid unintended consequences
  - Want to identify preferable materials (not just minimally acceptable)



Slides courtesy of Hewlett Packard

HP Uses GreenScreen to Choose Alternatives to Substances of Concern

- Select alternatives that won't be restricted in the future
  - E.g., Low toxicity
- Articulate materials goals to suppliers
  - Not simply saying what HP doesn't want
  - Defining what HP does want in its products

Green Screen Assessments of Similar Function Chemical

Common Name	CAS #	Full Name	Benchmark
Preferred			
Design	none	Design material out, dematerialize	4
Substance 0	#####-##-#	Chemical name	4
Use but still opportunity for improvement			
Substance 1	#####-##-#	Chemical name	3
Substance 2	#####-##-#	Chemical name	3
Use but search for alternatives			
Substance 3	#####-##-#	Chemical name	2
Substance 4	#####-##-#	Chemical name	2
Substance 5	#####-##-#	Chemical name	2
Substance 6	#####-##-#	Chemical name	2
DO NOT USE			
Substance 7	#####-##-#	Chemical name	1
Substance 8	#####-##-#	Chemical name	1
Substance 9	#####-##-#	Chemical name	1
Substance 10	#####-##-#	Chemical name	1
Substance 11	#####-##-#	Chemical name	1
Substance 12	#####-##-#	Chemical name	1

Slides courtesy of Hewlett Packard

PVC-Free Power Cord Green Screen Program

- Screening mandatory, in addition to all standard and regulatory requirements
- Full disclosure under CDA
- Over 30 materials screened
  - Several approved
- 100% of PVC-free power cords have been screened

Slides courtesy of Hewlett Packard

Ongoing

- Bringing more material types into program
- Promoting the use of the GreenScreen within the electronics industry and with formulators as a common tool
- Helping to incorporate GreenScreen ratings into ecolabels
- Helping with infrastructure to enable screening and sharing of results

Slides courtesy of Hewlett Packard

US Green Building Council LEED v4 Materials & Resources -- MRc4 Credit

MRc4: Building Product Disclosure and Optimization – material ingredients (July 2012) – may earn credit for either or both

- **Option 1. Material Ingredient Reporting (disclosure)**
  - Health Product Declaration (which uses GreenScreen List Translator)
  - Manufacturer disclosure with GreenScreen assessments of chemicals not disclosed

- **Option 2. Material Ingredient Optimization**
  - Products that have fully inventoried chemical ingredients to 100 ppm that have no Benchmark 1 hazards
    - Use GreenScreen List Translator (100% of cost)
    - Use full GreenScreen method (150% of cost)

GreenScreen Program Developments

1. *GS v1.2 FINAL Guidance – 9/11/2013*

Go to: http://www.cleanproduction.org/Greenscreen.v1-2.php

2. Licensed GS Profilers
3. GS Certified Practitioners
4. Verification Program
5. Automation of the GS List Translator
6. GreenScreen for nanomaterials

Licensed GreenScreen Profilers Perform GS Assessments as a Service to Clients

Demonstrate expertise, knowledge, competency and capacity

Margaret H. Whittaker, Ph.D., M.P.H., E.R.T., D.A.B.T., UK/EU
ToxServices LLC
www.toxservices.com

Teresa L. McGrath, Supervising Toxicologist
NSF International
www.nsf.org

Patricia Beattie, PhD, DABT
SciVera LLC
www.scivera.com/services.php

GS Verification Program Pilot

CHEMICAL PROFILE

VERIFICATION

COMMUNICATION

Self assess chemicals using the GS

- OR -

Engage licensed GS Profiler to assess chemicals using the GS

Verify NON VERIFIED GS Assessment via GS Verification Program

Generate NON VERIFIED GS assessment; May NOT use GS trademarks for public product claims

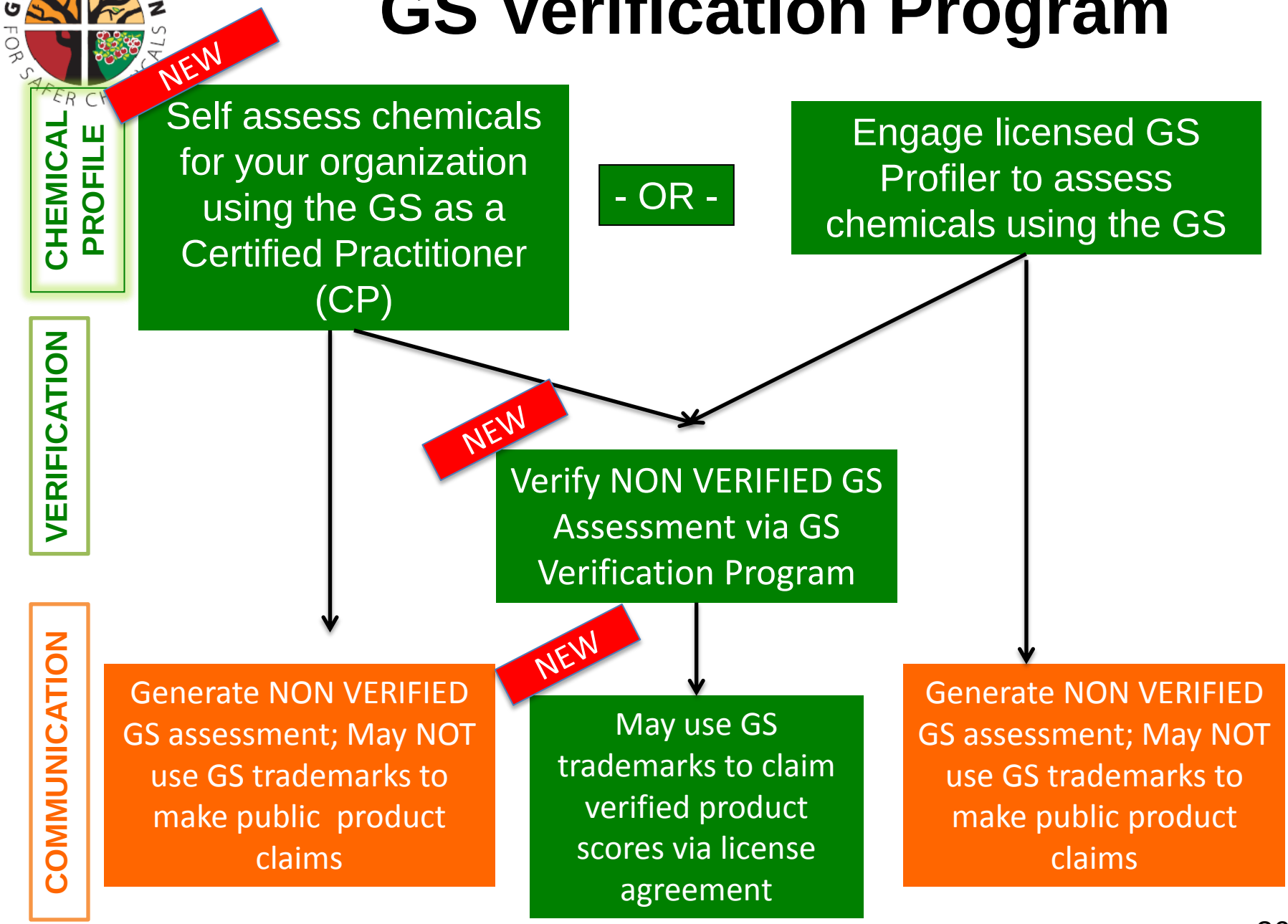
May use GS trademarks to claim verified product scores via license agreement

Generate NON VERIFIED GS assessment; May NOT use GS trademarks for public product claims

Certified Practitioner (CP) Training Program

- Individuals in organizations become certified to perform GS assessments for their organization
  - Eligible to submit GS assessments for verification
- Requirements include:
  - One day workshop (i.e. IN Training in Sept 2013)
  - Advanced GS Topics (available via webinars)
  - Practicum: perform 2 GS assessments with coaching by a GS Trainer
- Pilot underway, program to launch Q1 2014

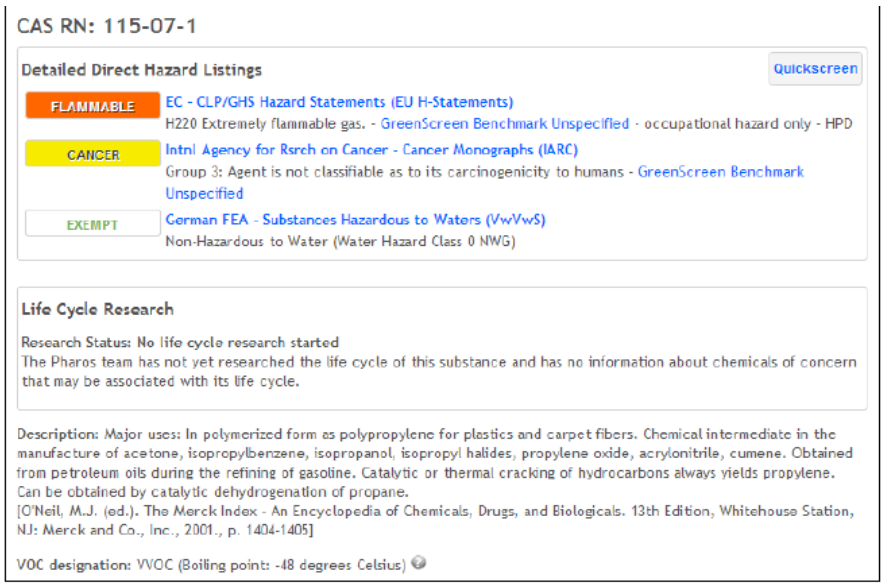
GS Verification Program



Automation of the GS List Translator: Software Partners

Healthy Building Network via Pharos (NGO)

The Wercs via GreenWERCS (for profit)

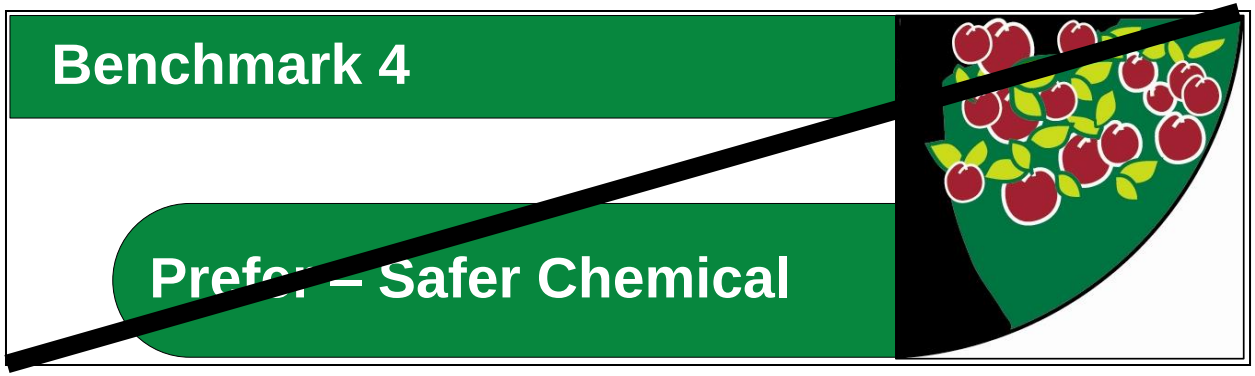


What GreenScreen List Translator Is

- Automated hazard list search tool that translates authoritative lists into GreenScreen criteria
- Identifies known “bad actor” chemicals using lists – GreenScreen Benchmark 1 chemicals

What the GreenScreen List Translator Isn't

- It does NOT include an assessment of data
- It does NOT represent a comprehensive review
- It does NOT review transformation products
- It does NOT identify safer chemicals – need to perform full GreenScreen assessment



The GreenScreen™ Tools

- **Full GreenScreen**
  - Systematic evaluation of chemical based on 18 hazard endpoints
  - Identifies inherently safer chemicals
  - Requires technical expertise
  - Best to use licensed profiler

GreenScreen List Translator

  - Readily identifies Benchmark 1 chemicals
  - Based on authoritative lists
  - Doesn’t require toxicology expertise

"The more you know about what you are putting into your products, the more likely you are to make better choices in product development"

Jonathan Plisco, PolyOne

Contact Info

Lauren Heine, Ph.D.

Consulting Co-Director, Director
GreenScreen Program

Clean Production Action

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