GreenScreen™ for Safer Chemistry

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NSF International
Global Leader in Public Health

- Independent, not-for-profit organization certifying products and systems for over 65 years
- Standards development in water, food, environment and other public health areas (>50 consensus ANSI standards)
- Headquartered in the US, with locations worldwide, servicing 12000 companies in 100 countries
- 55 chemists, 26 toxicologists, 30 engineers, 20 biologists
- Strong focus on commerce informed by collaborations with the US EPA, FDA, CDC, the World Health Organization as well as trade associations and other institutions around the globe.

Green Chemistry

NSF is third-party reviewer for:

- **NSF Sustainability Standards (carpet, resilient flooring, etc.)**
- **The U.S. EPA's Design for the Environment (DfE) Program**
- **Clean Production Action's GreenScreen™**

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12 Principles of Green Chemistry*

1. Prevention
2. Atom Economy
3. Less Hazardous Chemical Syntheses
4. Designing Safer Chemicals
5. Safer Solvents and Auxiliaries
6. Design for Energy Efficiency
7. Use of Renewable Feedstocks
8. Reduce Derivatives
9. Catalysis
10. Design for Degradation
11. Real-time analysis for Pollution Prevention
12. Inherently Safer Chemistry for Accident Prevention

* Anastas, P. T.; Warner, J. C.; Green Chemistry: Theory and Practice, Oxford University Press: New York, 1998, p.30. By permission of Oxford University Press

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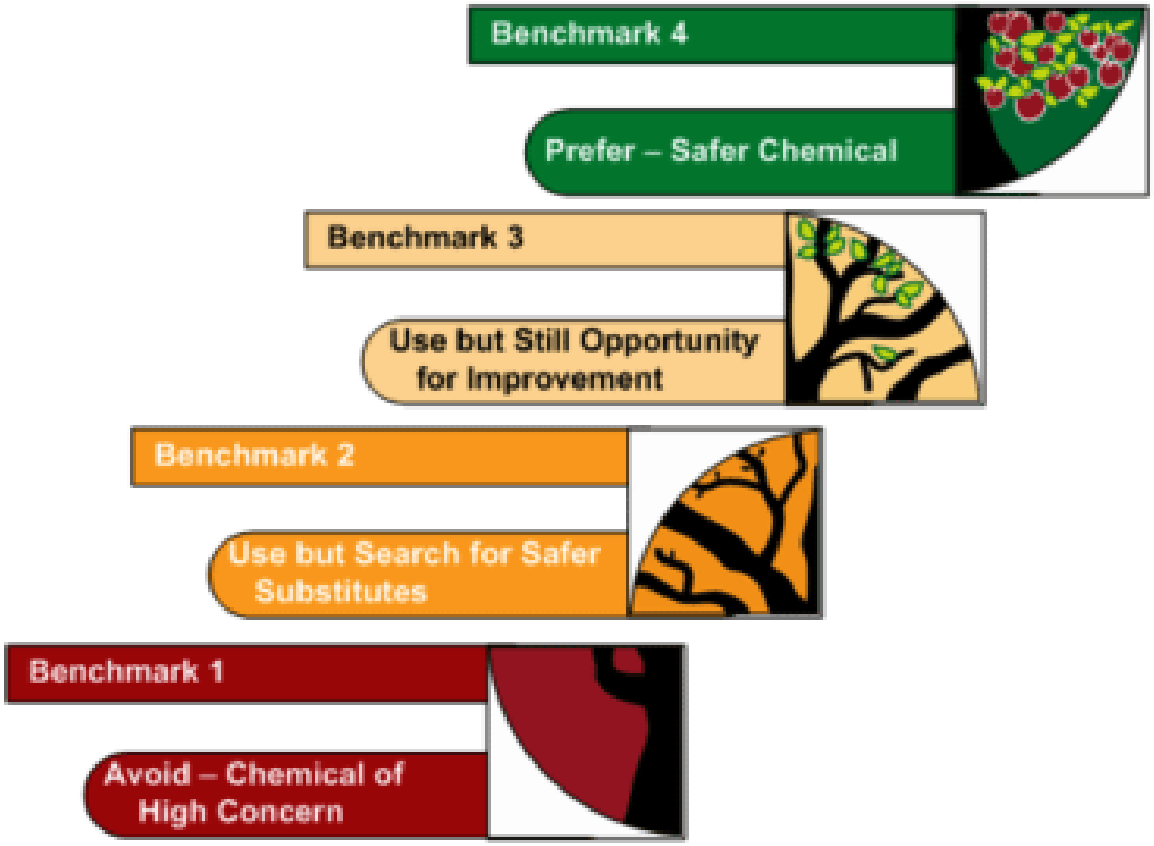
Clean Production Action - GreenScreen™

A Benchmark score facilitates informed decisions



NSF is a third-party licensed profiler and trainer for the GreenScreen™

What Determines a Benchmark Score?

- **Evaluate 18 hazard endpoints relative to human health and the environment**
- **Determine low, moderate or high hazard for each**
- **Apply the GreenScreen algorithm to consider:**
  - Transformation products
  - Genetic hazards that can pass to the next generation
  - Severity and potency of each hazard
  - Persistence (environmental and bioaccumulation in the food chain)
  - How much do we know about the chemical

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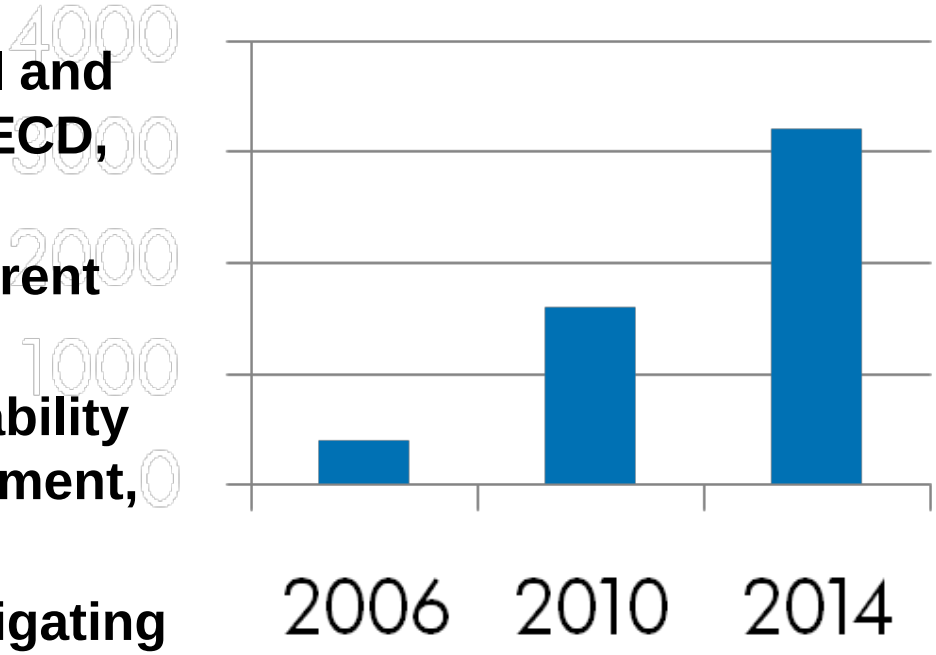
Which criteria are most relevant?

- **Builds on the USEPA DfE approach and other national and international precedents (OECD, GHS)**
- **Publicly accessible, transparent and peer reviewed**
- **Compliments other sustainability tools including Risk Assessment, Life Cycle Assessment, etc.**
- **Harmonization is key to navigating increasing regulations**
- **The GreenScreen is the most comprehensive tool currently available!**



REACH COMPLIANCE

RoHS 2002 95 EC

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Who is Using the GreenScreen™

Identifying safer substitutes for BFRs, CFRs, and PVC

Platform for their chemical screening program

Basis for state regulatory programs

Aligning hazard thresholds

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Drivers for the GreenScreen™

- **Upstream users in certain industries (electronics, textiles, automotive, building products)**
- **Corporate responsibility (Michigan companies - Green Chemistry Checklist)**
- **International sales**
- **Voluntary standards**
  - LEED certification – materials optimization
  - Health Product Declarations (HPDs)
- **California, Maine, Washington - regulations**

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A GreenScreen™ is NOT a Risk Assessment

- **Hazard = the *inherent property* of a substance having the potential to cause adverse effects when an organism, system or (sub) population is exposed to it.**

- **Risk = the *probability* of an adverse effect in an organism, system or (sub) population caused under specified circumstances by exposure to a substance.**

Risk = *f* (hazard, exposure)

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Steps in a GreenScreen®

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

Assess & Classify Hazards

a) Determine identity of chemical(s) to assess
   a) Processing chemicals
   b) Chemicals in your finished products
   c) Chemicals in your waste stream

a) Gather data

b) Classify hazard level for each hazard endpoint (e.g. **H**, **M** or **L**)

c) Fill in hazard summary table

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Populate Hazard Summary Table

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**	DG	**L**	**vH**	*H*	**L**	**L**	**L**	**L**	**H**	**H**	**vL**	**L**	*M*	*L*

Level of Concern:
- vH = very High
- L = Low
- H = High
- vL = very Low
- M = Moderate
- DG = Data Gap

Bold = High confidence
Italics = Low confidence

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Steps in a GreenScreen®

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

GreenScreen® Benchmark Criteria

ABBREVIATIONS

- **P** Persistence
- **B** Bioaccumulation
- **T** Human Toxicity and Ecotoxicity

This chemical passes all of the criteria.

BENCHMARK 4

Low P* + Low B + Low T (Ecotoxicity, Group I, II and II* Human) + Low Physical Hazards (Flammability and Reactivity) + Low (additional ecotoxicity endpoints when available)

Prefer—Safer Chemical

BENCHMARK 3

a. Moderate P or Moderate B
b. Moderate Ecotoxicity
c. Moderate T (Group II or II* Human)
d. Moderate Flammability or Moderate Reactivity

Use but Still Opportunity for Improvement

If this chemical and its breakdown products pass all of these criteria, then move on to Benchmark 4.

BENCHMARK 2

a. Moderate P + Moderate B + Moderate T (Ecotoxicity or Group I, II, or II* Human)
b. High P + High B
c. High P + Moderate T (Ecotoxicity or Group I, II, or II* Human)
d. High B + Moderate T (Ecotoxicity or Group I, II, or II* Human)
e. Moderate T (Group I Human)
f. Very High T (Ecotoxicity or Group II Human) or High T (Group II* Human)
g. High Flammability or High Reactivity

Use but Search for Safer Substitutes

If this chemical and its breakdown products pass all of these criteria, then move on to Benchmark 3.

BENCHMARK 1

a. PBT = High P + High B + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]
b. vPvB = very High P + very High B
c. vPT = very High P + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]
d. vBT = very High B + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]
e. High T (Group I Human)

Avoid—Chemical of High Concern

If this chemical and its breakdown products pass all of these criteria, then move on to Benchmark 2.

BENCHMARK U

- Unspecified Due to Insufficient Data

Aligned with Regulatory Drivers

GreenScreen® Benchmark 1 Criteria

BENCHMARK 1

a. PBT = High P + High B + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]

b. vPvB = very High P + very High B

c. vPT = very High P + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]

d. vBT = very High B + [very High T (Ecotoxicity or Group II Human) or High T (Group I or II* Human)]

e. High T (Group I Human)

Avoid—Chemical of High Concern

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36 Lists – available at www.greenscreenchemicals.org

Green Screen v1.2.1 List Translator 2012 0203- All [Compatibility Mode] - Microsoft Excel

GreenScreen™ for Safer Chemicals
Version 1.2 Specified Lists

February

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Last Updated 2012 0203

ID	Abbreviation	CPA List Type	Listed in DfE	List Name	Associated Green Screen Hazard Endpoints	URL and/or Reference
1	AOEC	Authoritative	Yes	Association of Occupational and Environmental Clinics (AOEC) Exposure Code List	Sensitization (respiratory including asthma)	http://www.aoecdata.org/ExpCodeLookup.aspx (accessed 9/14/11)
2	Boyes-N	Screening	No	A list of the chemicals for which NIOSH or OSHA have established workplace exposure standards on the basis of effects on the nervous system is presented in Table 25.1 (adapted from Ref. 26).	Reproductive and Developmental Toxicity including Developmental Neurotoxicity, Neurotoxicity	Neurotoxicology and Behavior William K. Boyes, Ph.D. Eula Bingham, Barbara Cohrssen, Charles H. Powell (eds.), Patty's Toxicology Copyright © 2001 by John Wiley & Sons, Inc. All rights reserved. DOI: 10.1002/0471435139.tox025 Article Online Posting Date: April 16, 2001
3	CEPA	Screening	No	Canadian Environmental Protection Act, 1999 (CEPA 1999): CEPA Toxic	All human health and environmental toxicity and fate endpoints	[CEPA Toxic Substance List - Schedule 1] http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&xml=4ABEFFC8-5BEC-B57A-F4BF-11069545E434 (accessed 9/14/11); [CEPA main page] http://www.ec.gc.ca/ceparegistry (accessed 9/14/11); [CEPA Notices general] http://www.ec.gc.ca/substances/ese/eng/dsl/notices_avis.cfm (accessed 9/14/11); [CEPA Environmental Registry] http://www.ec.gc.ca/CEPARegistry/subs_list/dsl/dslsearch.cfm (accessed 9/14/11)

List Definitions | Specified Lists | Human & Ecotox Single | Multiple Endpoints | Flammability, Reactivity Single | BM1 | Possible BM 1

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Some List Designations = Benchmark 1

Green Screen v1.2.1 List Translator 2012 0203- All [Compatibility Mode] - Microsoft Excel

B154 G&L

GreenScreen™ v1.2 List Translator - Human Health Single Endpoints

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Notes: 1. For the purposes of benchmarking, the value ___ was used. (1)vH; (2)H; (3)M; (4)L ; vH = very High; H = High; M = Moderate; = Low; vL = very Low; U = Unspecified (U can be used for both hazard classification and Benchmark Scores) 2. Report lowest Benchmark

Last Updated 2012 0203

	GreenScreen Supporting List Information			GreenScreen List Translator					
	ID	List	List Category	Green Screen Hazard	List Type	A or B	Hazard Range	Display in Hazard Box (See Notes	Benchmark Score
152	149	EU SVHC	Reason for inclusion: Mutagenic	Mutagenicity/Genotoxicity	Authoritative	A	H	**H**	**1**
153	150	EU SVHC	Reason for Inclusion: Other concern - Endocrine Activity	Endocrine Activity	Authoritative	A	H	**H**	**1**
154	151	G&L	Developmental Neurotoxicant	Developmental Toxicity	Screening	B	H or M	*H or M (3)*	**1 or 2**
155	152	G&L	Neurotoxicant	Neurotoxicity-Any Expo	Screening	B	vH, H, or M	*U*	**U**
156	153	IARC	Group 1: Agent is carcinogenic to humans	Carcinogenicity	Authoritative	A	H	**H**	**1**
157	154	IARC	Group 2A: Agent is probably carcinogenic to humans	Carcinogenicity	Authoritative	A	H	**H**	**1**
158	155	IARC	Group 3: Not classifiable as to carcinogenicity to humans	Carcinogenicity	Authoritative	B	H, M or L	*U*	**U**

List Definitions | Specified Lists | Human & Ecotox Single | Multiple Endpoints | Flammability, Reactivity Single | BM1 | Possible BM 1

Ready 125%

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List Translator Scores

GS LT Score*	GreenScreen Benchmark Equivalency	Derivation
LT-1	Benchmark 1	A LT-1 chemical score is based on lists that identify it is a Chemical of High Concern and may be considered equivalent to a Benchmark 1 chemical using the full GreenScreen method*.
LT-P1	Possible Benchmark 1	A LT-P1 chemical score translates to Possible BM1 and reflects the presence of the chemical on Screening A or B lists and some uncertainty about the classification for key endpoints. Further research is needed on the flagged endpoint to determine if the chemical is indeed a GreenScreen Benchmark 1.
LT-U	Unspecified Benchmark	A LT-U chemical score indicates that there is insufficient information to apply the GreenScreen Benchmark Scoring algorithm to the chemical. That can be a good sign. Typically, only hazardous chemicals are found on hazard lists. However, lack of presence on hazard lists can also mean that the chemical has not been well tested. Therefore the resulting conclusion using the List Translator is that the Benchmark U score is Unspecified pending full GreenScreen review. A full GreenScreen assessment will need to be performed to determine if a chemical is a Benchmark 2, 3 or 4.

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pharos project :: material_chm :: formaldehyde - Windows Internet Explorer provided by NSF International
http://www.pharosproject.net/material_chm/show/materialId/50-00-0
pharos project :: material_ch...
Convert Select

FORMALDEHYDE

CAS RN: 50-00-0

View Products

Direct Chemical and Compound Hazard Quickscreen

Detailed Hazard Listings

Very High Hazard of...

MAMMALIAN — US EPA - Extremely Hazardous Substances (EPA-AMT): Extremely Hazardous Substances - GreenScreen Benchmark Unspecified (LT-U) {and 17 others}

SKIN IRRITATION — EC - CLP/GHS Hazard Statements (EU H-Statements): H314 Causes severe skin burns and eye damage - GreenScreen Benchmark Unspecified (LT-U) {and 4 others}

High Hazard of...

CANCER — Intnl Agency for Rsrch on Cancer - Cancer Monographs (IARC): Group 1: Agent is carcinogenic to humans - GreenScreen Benchmark 1 (LT-1) {and 11 others}

RESPIRATORY — AOEC - Asthmagens (AOEC): Asthmagen (AG) - generally accepted - GreenScreen Benchmark Unspecified (LT-U) {and 3 others}

EYE IRRITATION — Japan METI/MOE - GHS Classifications (GHS-Japan): Serious eye damage / eye irritation - Category 2A - GreenScreen Benchmark Unspecified (LT-U)

SKIN SENSITIZE — German MAK - List of Substances (MAK): Sensitizing Substance Sh - Danger of skin sensitization - GreenScreen Benchmark Unspecified (LT-U) {and 3 others}

ACUTE AQUATIC — Korea NIER - GHS Classification (GHS-Korea): Hazardous to the aquatic environment (acute) - Category 1 [H400 - Very toxic to aquatic life] - GreenScreen Benchmark Unspecified (LT-U) {and 1 other}

FLAMMABLE — Québec CSST - WHMIS Classifications (WHMIS): Class B1 - Flammable gases - GreenScreen Benchmark Unspecified (LT-U) {and 1 other}

Medium Hazard of...

DEVELOPMENTAL — German MAK - List of Substances (MAK): Pregnancy Risk Group C - GreenScreen Benchmark Unspecified (LT-U)

Compound G
This chemical i compound grou
Formaldehyde

GreenScreen
Highest concern GreenScreen Be
Highest concern Benchmark 1 (L

Tags for this
There are no ta
Add a Ne

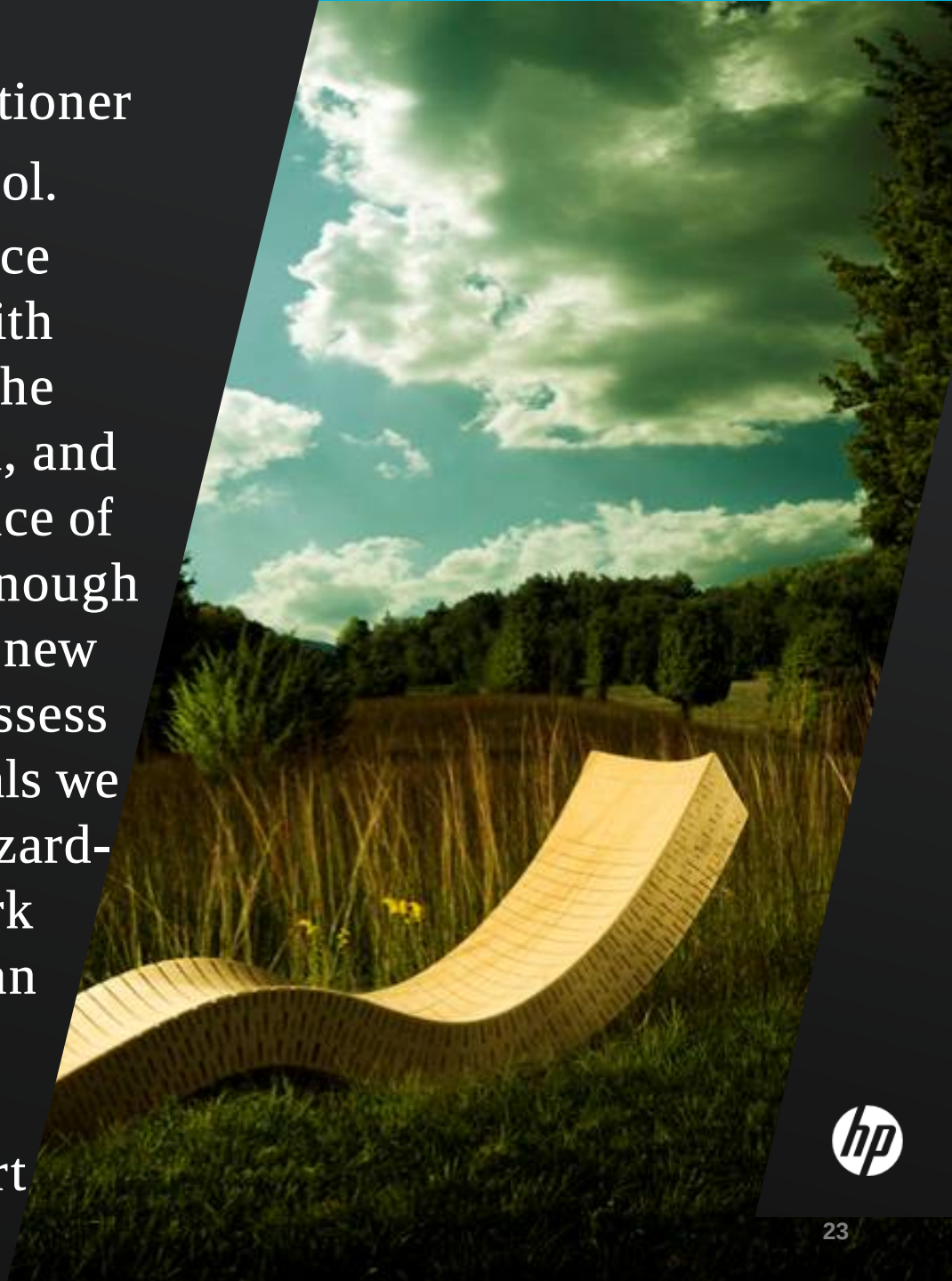
Steps in a GreenScreen®

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

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



ROHS – The Law that Changed Everything

•**EU Directive 2002/95/EC on the Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment**

Logo from companion regulation Waste Electrical and Electronic Equipment (WEEE) Directive

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More Regulations Coming

Substance restrictions have become a major class of regulation for finished electronic products

- More substances
- More jurisdictions
- More reporting

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Companies Implemented RoHS Restrictions

Material selection based on:

- Cost
- Function
- Reliability
- Manufacturability

All unregulated substitutes equally acceptable

Bad idea!

1 July 2006

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Avoid Regrettable Substitutions

Don’t replace a chemical of concern with an unknown

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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)

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SUBSPORT – SUBSTITUTION SUPPORT PORTAL - Windows Internet Explorer provided by NSF International

http://www.subsport.eu/

SUBSPORT – SUBSTITU... | SUBSPORT - Case Story

Convert | Select

SUBSPORT
Substitution Support Portal

MOVING TOWARDS SAFER ALTERNATIVES

Support for Substitution

Substitution of hazardous chemicals is a fundamental measure to reduce risks to environment, workers, consumers and public health.

Legislation encourages you to substitute, this site will show you how.

Read more

Latest News

Substitution of hazardous chemicals - regulation-driven innovation

Events & Training | 23.05.2014

The Public Research Centre Henri Tudor and the REACH&CLP Helpdesk Luxembourg offer this conference on 26 June 2014 at the Chambre of Commerce Luxembourg addressing especially small and medium sized enterprises. SUBSPORT will present tools to support substitution in practice.

Read more

Substitution Steps

Substitution may be fast and easy or a more complex process. Generally it includes the following steps:

1. Define the problem
2. Set substitution criteria
3. Search for alternatives
4. Assess and compare alternatives
5. Experiment on pilot
6. Implement and improve

Read more

How to Substitute

- **Use GreenScreen to identify chemicals of concern already in your products**
- **Set requirements for potential alternatives (e.g. =>BM2 for any BM1, plus other considerations – cost and availability, functionality, life cycle impact, etc.)**
- **Green Screen results are only part of decision, but initial hazard screening deselects certain options early in assessment process**
- **See www.subsport.eu for guidance (previous slide)**

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Get Help – Engage Stakeholders

- **Trade associations** can help pool resources:
  - PINFA examined several non-brominated flame retardants
  - GC3 examined plasticizers

Ø Successfully differentiated alternatives

Ø Identified better (and unacceptable) options

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

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Next Steps

- **GreenScreen training is available** (www.greenscreenchemicals.org)
  - 1-day workshops, or
  - web-based Advanced Practitioners Course
- **Start with the GreenScreen List Translator™** available at above link
  - Quickly identify known Benchmark 1's (i.e. substances that are known carcinogens, reproductive toxicants, PBT's etc. from the most well known lists such as IARC, Prop 65, OSPAR…aka LT-1 on next slide)
  - Quickly identify possible Benchmark 1's (aka LT-P1) and confirm they are not BM1's
  - After you rule out the known BM1's, deal with the rest of your inventory on a tiered schedule

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Automated GreenScreen List Translator

- **Pharos –** online database developed by the Healthy Building Network www.pharosproject.net – affordable and easy-to-use ListTranslator tool
- **GreenWercs –** www.thewercs.com, more costly than Pharos in terms of annual subscription rates, but has many additional functionalities beyond the GreenScreen and List Translator

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Challenges for the GreenScreen™

1. **ListTranslator screens are quick and affordable, but full GreenScreens are time consuming**
2. **Full GreenScreens require training <u>and</u> toxicology knowledge**
3. **Supplier disclosures – you can't rank an unknown**
4. **Knowing where to find data**
   a. How to perform a comprehensive literature search
   b. How to strategically sift through mountains of data
   c. How to deal with data integrity
   d. How to identify transformation products
5. **Lack of data**
   a. How to identify analogs
   b. How to fill data gaps with SAR modeling

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NSF GreenScreen™ Services

Inventory pre-screens using ListTranslator

- –Useful for company stewardship and planning
- –Useful for R&D
- –Health Product Declarations

Prioritize ingredients for full GreenScreens

Screen proprietary ingredients for supplier confidentiality

Review critical studies for data integrity and conclusions

- –Some companies do not have toxicologists on staff

Identify transformation products

Fill data gaps

- –Identifying analogs
- –Perform SAR modeling

Full GreenScreens

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Exercise – Making Informed Decisions

Alternates	GreenScreen™ Hazard Ratings: possible alternatives for a Benchmark 1 polymer																				
		Group I Human					Group II and II* Human									Ecotox		Fate		Physical	
								Systemic Toxicity		Neuro-toxicity											
	Benchmark Score	Cancer	Mutagenicity	Reproductive	Developmental	Endocrine	Acute Toxicity	Single	Repeated	Single	Repeated	Skin Sensitization	Respiratory	Skin Irritation	Eye Irritation	Acute Aquatic	Chronic Aquatic	Persistence	Bioaccumulation	Reactivity	Flammability
Alternate #1 (CAS xxxx-xx-x)	2	**L**	**L**	DG	*M*	*M*	**M**	DG	*M*	DG	DG	**L**	DG	*H*	*vH*	**vH**	*vH*	*H*	**L**	**L**	**L**
Alternate #2 (CAS xxxx-xx-x)	2	**L**	*M*	*L*	*M*	DG	**M**	DG	**H**	**M**	**L**	**L**	DG	**L**	*H*	**vH**	**M**	*M*	*L*	**L**	**L**
Alternate #3 (CAS xxxx-xx-x)	2	**M**	**L**	**L**	**L**	DG	*H*	**vH**	**H**	DG	DG	**L**	DG	**H**	**H**	**L**	**L**	*H*	*vL*	**L**	**M**

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Questions?

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