Agenda

• What is the GreenScreen for Safer Chemicals?
• How can the GreenScreen promote chemical optimization throughout the supply chain?
• What are new developments in GreenScreen methodology?
• How does GreenScreen fit into our shared goal of sourcing safer chemicals in products?

http://www.wordclouds.com/

Word cloud of BizNGO brochure
What is the GreenScreen?

• The GreenScreen is a comparative Chemical Hazard Assessment (CHA) method developed by Clean Production Action
  – Most current method is version 1.2
  – GreenScreen was released on March 20, 2007
• Builds on the U.S. EPA DfE Alternatives Assessment approach and other national and international precedents (OECD, GHS)
• GreenScreen is freely and publicly accessible, transparent, and peer reviewed
• GreenScreen complements other sustainability tools:
  • Based on Green Chemistry Principles
  • Supports Risk Assessment
  • Complements Life Cycle Assessment
  • A key part of Alternatives Assessment

All supporting resources at: http://www.greenscreenchemicals.org/
What is the GreenScreen?

There are two levels of assessment

- **GreenScreen List Translator**
  - Automated tool that screens the chemicals against specified authoritative and screening lists
  - Scores: LT-1 (equivalent to BM-1), LT-P1, LT-U
  - Quickly identifies chemicals to avoid and why
  - Easily accessible, automated tool
  - Useful tool for identifying “known” bads; not as useful for newly developed chemicals

- **Full GreenScreen assessment**
  - Scientists (usually toxicologists) prepare full GreenScreen assessment
  - CPA Licensed Profilers most qualified (see [http://www.greenscreenchemicals.org/](http://www.greenscreenchemicals.org/)) for list of qualified profilers
  - Comprises selection, review, and integration of chemical data and modeling into comprehensive assessment of a minimum of 18 hazard endpoints
The GreenScreen List Translator

GreenScreen List Translator

• Readily identifies chemicals of concern
• Based on authoritative lists
• Doesn’t require toxicology expertise
• Used to identify GreenScreen Benchmark 1 Chemicals
  • LT-1 chemicals are Benchmark 1 chemicals (unless proven otherwise)
  • LT-P1 chemicals may be Benchmark 1 chemicals
  • LT-U chemicals are not known to be Benchmark 1 need further assessment to determine Benchmark score

Obtaining GreenScreen List Translator

Manual Version:
http://http://www.greenscreenchemicals.org/method/greenscreen-list-translator

Automated Tool: Incorporated into Pharos
http://www.pharosproject.net/

1,4-Dichlorobenzene is a List Translator-1 (LT-1) Chemical
Three Steps to Safer Chemicals: GreenScreen

1. Assess and classify hazards
2. Apply the Benchmarks
3. Make informed decisions
Step 1: Assess & Classify Hazards

a) Identify chemical constituents along with relevant and feasible transformation products

b) Collect and evaluate data from all relevant sources (using test data, literature, models, analogs, hazard lists, etc.) for the chemical under assessment

c) Assign level of concern (e.g., vH, H, M, L) and level of confidence for each hazard endpoint

d) Complete a hazard table for each of the 18 screened endpoints

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Group I Human</th>
<th>Group II Human</th>
<th>Ecotox</th>
<th>Fate</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C  M  R  D  E</td>
<td>AT  ST  N  SnS</td>
<td>SnR  IrS  IrE</td>
<td>AA  CA</td>
<td>P  B  Rx  F</td>
</tr>
<tr>
<td>Chemical 1</td>
<td>M  L  L  M  M</td>
<td>L  L  M  L  DG</td>
<td>L  H  L  L  vH  M  L  L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical 2</td>
<td>L  L  M  M  H</td>
<td>L  H  M  L  L  M  M</td>
<td>H  H  vH  vH  L  L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical 3</td>
<td>L  L  M  H  DG</td>
<td>L  H  DG  L  DG</td>
<td>L  L  DG  M  M  L  M</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Level of Confidence**
- Bold H, M, or L = measured data or high quality surrogate
- DG = data gap
- Italic H, M, or L = estimated data (analog or model)
Step 2: Identify Benchmark Score from Hazard Classifications

The combination of hazard classifications for 18 assessed endpoints (Step 1) translates into a Benchmark score ranging from 1-4.

A Benchmark score supports decision-making:
- BM1 – phase out
- BM2 – manage to use safely
- BM3 – getting there
- BM4 – inherently low hazard

**Benchmark U** = Undetermined due to insufficient data

Aligned with Regulatory Drivers
Step 2, cont’d: Benchmark 2 Chemical

<table>
<thead>
<tr>
<th>Carcinogenicity</th>
<th>Mutagenicity/Genotoxicity</th>
<th>Reproductive Toxicity</th>
<th>Developmental Toxicity</th>
<th>Endocrine Activity</th>
<th>Acute Toxicity</th>
<th>Systemic Toxicity</th>
<th>Neurotoxicity</th>
<th>Skin Sensitization*</th>
<th>Respiratory Sensitization*</th>
<th>Skin Irritation</th>
<th>Eye Irritation</th>
<th>Acute Aquatic Toxicity</th>
<th>Aquatic Toxicity</th>
<th>Persistence</th>
<th>Cumulation</th>
<th>Toxicity</th>
<th>Flammability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I Human</td>
<td>Group II and II* Human</td>
<td>Ecotox</td>
<td>Fate</td>
<td>Physical</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Chemical A is a BM 2 chemical -- Meets BM 2e classification -- Meets BM 2f classification

GS 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

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>GreenScreen Benchmark</th>
<th>Rationale</th>
</tr>
</thead>
</table>
| Chemical A    | 2 - Orange            | 2e. Moderate Mutagenicity/Genotoxicity  
2f. High Systemic Toxicity - Repeated Exposure |
Step 3: Making Informed Decisions

- GreenScreen scores can be used without toxicology training
- Use a chemical’s full GreenScreen hazard table, not just the Benchmark score when comparing hazards of chemicals
- Consider the chemical’s specific application and use
- Apply Risk Management as part of your decision-making

As we’ve heard earlier in the conference, all chemicals need risk management, but it’s a lot easier with inherently safer chemicals...
Using GreenScreen to Promote Chemical Optimization throughout the Supply Chain

GreenScreen drives chemical optimization:

- RSL/MRSL creation
- Preferred materials/positive lists
- Integral part of alternatives assessments
- Guide new product development
- Part of ecolabels and standards
GreenScreen is used to populate Restricted Substances Lists (RSLs) as well as Manufacturing Restricted Substances Lists (MRSLs)

- An MRSL differs from an RSL: An MRSL restricts levels of hazardous substances in formulations used and potentially discharged into the environment during manufacturing, not just chemicals present in finished products.
- MRSLs are important for industries that utilize formulations that can be released to the environment in large quantities (textile, apparel, footwear sectors).

The Zero Discharge of Hazardous Chemicals (ZDHC) coalition included GreenScreen and GreenScreen List Translator as part of creating the ZDHC MRSL (http://www.roadmaptozero.com/programme-documents/)
Driving Hazard Reduction in Supply Chain: Positive Lists

- Levi Strauss & Co. uses GreenScreen for formulations used throughout the textile manufacturing process

<table>
<thead>
<tr>
<th>Chemical (FMDC#)</th>
<th>CAS RN</th>
<th>Functional use</th>
<th>% in Ingredient</th>
<th>Carcinogenicity</th>
<th>Mutagenicity</th>
<th>Reproductive</th>
<th>Developmental</th>
<th>Endocrine Activity</th>
<th>Acute Toxicity</th>
<th>Acute Aquatic</th>
<th>Chronic Aquatic</th>
<th>Persistence</th>
<th>Bioaccumulation</th>
<th>Reactivity</th>
<th>Flammability</th>
<th>GreenScreen® Benchmark Score, SCP Screen Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>(FMDC-634)</td>
<td>[REDACTED]</td>
<td>Carrier</td>
<td>Redacted</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>U.S. EPA SCIL Full Green Circle</td>
</tr>
<tr>
<td>(FMDC-604)</td>
<td>[REDACTED]</td>
<td>Mediator</td>
<td>Redacted</td>
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<td>L</td>
<td>DG</td>
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<td>DG</td>
<td>L</td>
<td>DG</td>
<td>DG</td>
<td>M</td>
<td>DG</td>
<td>H</td>
</tr>
</tbody>
</table>
GreenScreen in Alternatives Assessments

A Chemical Hazard Assessment is a critical component of a Chemical Alternatives Assessment (CAA)

- A CHA can be performed as part or independently of a full CAA

The Six Steps of a CAA are shown below:

- **Chemical hazard assessment (CHA):** a systematic process of assessing and classifying hazards across an entire spectrum of endpoints and severity
- Life cycle thinking
- Exposure assessment
- Technical/functional assessment
- Economic assessment
- Social impact assessment
GreenScreen was recently used as part of a BizNGO project to:

(1) Identify less hazardous alternatives to methylene chloride in paint stripper products

(2) Identify candidate alternatives for methylene chloride in paint stripping formulations that will likely be considered in actual/future Stage 1 submissions for this “priority product” in California; and

(3) identify challenges and needs confronting compliance with the California SCP alternatives analysis process

GreenScreen in Alternatives Assessments

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>CASRN</th>
<th>C</th>
<th>M</th>
<th>R</th>
<th>D</th>
<th>E</th>
<th>AT</th>
<th>ST</th>
<th>N</th>
<th>SnS</th>
<th>SnR</th>
<th>IrS</th>
<th>IrE</th>
<th>AA</th>
<th>CA</th>
<th>P</th>
<th>B</th>
<th>RX</th>
<th>F</th>
<th>Benchmark Score</th>
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<tbody>
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<td>Methylene chloride</td>
<td>75-09-2</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>DG</td>
<td>DG</td>
<td>M</td>
<td>M</td>
<td>vH</td>
<td>vH</td>
<td>L</td>
<td>DG</td>
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<td>H</td>
<td>M</td>
<td>L</td>
<td>vH</td>
<td>vL</td>
</tr>
<tr>
<td>Benzyl alcohol</td>
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<td>L</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>DG</td>
<td>DG</td>
<td>M</td>
<td>M</td>
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<td>L</td>
<td>L</td>
<td>L</td>
<td>vL</td>
<td>vL</td>
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<tr>
<td>2-(2-butoxyethoxy) ethanol</td>
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<td>L</td>
<td>L</td>
<td>L</td>
<td>M</td>
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<td>DG</td>
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<td>M</td>
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<td>L</td>
<td>vL</td>
<td>vL</td>
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<td>M</td>
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<td>Dimethyl sulfoxide</td>
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<td>L</td>
<td>M</td>
<td>M</td>
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<td>M</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>vL</td>
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<tr>
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<td>M</td>
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<td>L</td>
<td>L</td>
<td>vL</td>
<td>L</td>
<td>H</td>
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<td>Estanol (dibasic esters mixture)</td>
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<td>L</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>M</td>
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<td>DG</td>
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<td>L</td>
<td>L</td>
<td>vL</td>
<td>vL</td>
<td>M</td>
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<tr>
<td>d-Limonene</td>
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<td>L</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>L</td>
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<td>DG</td>
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<td>H</td>
<td>H</td>
<td>vH</td>
<td>H</td>
<td>vL</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Acetone</td>
<td>67-64-1</td>
<td>L</td>
<td>L</td>
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<td>M</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>vL</td>
<td>vL</td>
<td>L</td>
<td>H</td>
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<tr>
<td>Methanol</td>
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<td>H</td>
<td>vH</td>
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<td>NA</td>
<td>L</td>
<td>L</td>
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<td>L</td>
<td>vL</td>
<td>vL</td>
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<td>NA</td>
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<tr>
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<td>DG</td>
<td>L</td>
<td>H</td>
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<td>M</td>
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<td>H</td>
<td>H</td>
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<td>H</td>
<td>vL</td>
<td>L</td>
<td>H</td>
<td>1</td>
</tr>
<tr>
<td>Formic acid</td>
<td>64-18-6</td>
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<td>M</td>
<td>M</td>
<td>L</td>
<td>H</td>
<td>M</td>
<td>M</td>
<td>vH</td>
<td>vH</td>
<td>DG</td>
<td>L</td>
<td>DG</td>
<td>vH</td>
<td>vH</td>
<td>M</td>
<td>vL</td>
<td>vL</td>
</tr>
<tr>
<td>Caustic soda</td>
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<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>DG</td>
<td>vH</td>
<td>vH</td>
<td>vH</td>
<td>vH</td>
<td>M</td>
<td>M</td>
<td>DG</td>
<td>L</td>
<td>vL</td>
<td>M</td>
</tr>
</tbody>
</table>
GreenScreen in Alternatives Assessments

- Two alternatives (methanol and toluene) were screened out due to high developmental/reproductive toxicity (BM 1 scores for each)
- The remaining alternatives were safer, yet not free of hazards
  - DMSO has the lowest hazard profile (BM 3), but it can potentiate the hazards of other substances
- The project demonstrated that GreenScreen® is a useful tool in assessment in alternatives assessment
- Additional information about a substance – such as conditions of use – needs to be considered in addition to hazard

### Chemical Benchmark Score

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Benchmark Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylene chloride</td>
<td>1</td>
</tr>
<tr>
<td>Benzyl alcohol</td>
<td>2</td>
</tr>
<tr>
<td>2-(2-Butoxyethoxy) ethanol</td>
<td>2</td>
</tr>
<tr>
<td>Dimethyl sulfoxide (DMSO)</td>
<td>3</td>
</tr>
<tr>
<td>1,3-Dioxolane</td>
<td>2</td>
</tr>
<tr>
<td>Estasol (dibasic esters mixture)</td>
<td>2</td>
</tr>
<tr>
<td>d-Limonene</td>
<td>2</td>
</tr>
<tr>
<td>Acetone</td>
<td>2</td>
</tr>
<tr>
<td>Methanol</td>
<td>1</td>
</tr>
<tr>
<td>Toluene</td>
<td>1</td>
</tr>
<tr>
<td>Formic acid</td>
<td>2</td>
</tr>
<tr>
<td>Caustic soda</td>
<td>2</td>
</tr>
</tbody>
</table>

GreenScreen is now incorporated into multiple ecolabels and standards:

- **TCO Certified Displays Standard 7.0** now requires all non-halogenated flame retardants to be assessed and have a Benchmark score of ≥ 2
  - [http://tcodevelopment.com/](http://tcodevelopment.com/)
- **U.S. Green Building Council Leadership in Energy & Environmental Design (LEED)** specifies GreenScreen and GreenScreen List Translator to obtain different credits:
  - LEED v4 Option 1: Material Ingredient Reporting (1 point), and Option 2: Optimization (1 point)
What are New Developments in Tools to Select Safer Chemicals?

1. Terrestrial Toxicity
2. Automated Mixtures Tool
3. Benchmark 1 Alerts

THE ONLY THING CONSTANT IN LIFE IS CHANGE
HERACLITUS
Incorporating Terrestrial Toxicity Endpoints into GreenScreen

<table>
<thead>
<tr>
<th>Human Health Group I</th>
<th>Human Health Group II and II*</th>
<th>Environmental Toxicity &amp; Fate</th>
<th>Physical Hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcinogenicity</td>
<td>Acute Toxicity</td>
<td>Acute Aquatic Toxicity</td>
<td>Reactivity</td>
</tr>
<tr>
<td>Mutagenicity &amp; Genotoxicity</td>
<td>Systemic Toxicity &amp; Organ Effects</td>
<td>Chronic Aquatic Toxicity</td>
<td>Flammability</td>
</tr>
<tr>
<td>Reproductive Toxicity</td>
<td>Neurotoxicity</td>
<td>Other Ecotoxicity Studies when available*</td>
<td></td>
</tr>
<tr>
<td>Developmental Toxicity</td>
<td>Skin Sensitization</td>
<td>Persistence</td>
<td></td>
</tr>
<tr>
<td>Endocrine Activity</td>
<td>Skin Irritation</td>
<td>Bioaccumulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Eye Irritation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Standard GreenScreens evaluate aquatic toxicity for environmental toxicity

- The GreenScreen procedure specifies that additional ecotoxicity endpoints may be included when relevant.
- Terrestrial/Foliar Invertebrate toxicity is the ability of a chemical to pose an adverse health effect to a species that lives on land (bees, birds, soil organisms).
- Three neonicotinoid pesticides were GreenScreened and assessed terrestrial and bird and bee toxicity.
  - Evaluating “other” ecotoxicity studies is relevant because these formulations are applied to crops.
Neonicotinoids (also called “neonics”) are a relatively new type of insecticide, marketed in the last 20 years:

- Used to control sap-feeding insects, such as aphids on cereals and root-feeding grubs
- They are systemic pesticides and are taken up by the plant and remain active in the plant for many weeks
- Neonicots are the most widely used insecticides worldwide – their total share of the global market for insecticides is at least 30% and is worth at least $2.6 billion
- Neonicots don’t kill bees, instead they impair a bee’s ability to learn, navigate, forage for nectar, and reproduce
Three neonics were GreenScreened, and DfE Alternatives Assessment terrestrial toxicity criteria were incorporated
– All three neonics were BM 1 chemicals

<table>
<thead>
<tr>
<th>Group I Human</th>
<th>Group II and II* Human</th>
<th>Ecotox</th>
<th>Fate</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>M</td>
<td>R</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>Imidacloprid</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Thiamethoxam</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Clothianidin</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>M</td>
</tr>
</tbody>
</table>

Acute Terrestrial Vertebrates Toxicity Score (ATV) Score (vH, H, M, or L): Includes birds and mammals
Acute Foliar Invertebrates and Pollinators (AFI) Toxicity Score (H, M, or L): Includes bees

**Because the maximum score for AFI toxicity per DfE criteria is a High, a score of High was considered equivalent to a Very High for this endpoint for benchmarking purposes**
The consideration of mixture toxicities is addressed within CLP Regulation 1272/2008 and GHS.

- GHS in the EU was implemented in Regulation (EC) No. 1272/2008 on Classification, Labelling and Packaging of Substances and Mixtures (CLP Regulation) which is legally binding and directly applicable in the Member States of the EU, whereas GHS is not legally binding.

- GHS and CLP are not identical
  - Although CLP is based UN GHS “building block approach”, it does not include all the hazard categories included for a hazard class
    - e.g., category 4 of the hazard class for flammable liquids, or category 3 (mild irritant) of the hazard class for skin corrosion/irritation.
Tool #2: Incorporating CLP Mixture Criteria into GreenScreen

- Most chemical exposure occurs in the presence of multiple chemicals
  - However, most hazard and risk assessments are conducted on single chemicals
  - It is unrealistic to test every possible combination of chemicals
- GreenScreening mixtures
  - Most of the time, data on a mixture are not available and therefore, assessment of the GreenScreen’s 18 hazard endpoints is not possible for an overall discrete chemical formulation
  - a Benchmark score of U (“Hazard Unassignable”) is usually assigned for a mixture.
- Applying CLP’s approach (additive/non-additive) of classifying hazards in a mixture is being investigated in order to assign an overall benchmark (BM) score for a mixture.
Incorporating CLP Mixture Criteria into GreenScreen

• Each of the 18 GreenScreen hazard endpoints in a mixture will receive a classification of concern ranging from High to Low based on CLP’s mixture criteria for each hazard endpoint.

• The mixture score for each endpoint is automatically entered into the GreenScreen Inspector™ Tool to automatically derive an overall Benchmark score for the mixture.
  – This automated tool is undergoing peer review.
Classifying a Mixture Under CLP/GHS

Are available test data for the mixture sufficient for classification?

Yes → Classify the mixture for the relevant hazard

No →

Is there data available on similar tested mixtures and individual hazardous ingredients?

Yes → Is it possible to apply any of the bridging principles?

No →

Are hazard data available for all or some ingredients?

Yes → Use calculation or cut-off value/concentration limits to classify? (Additive and non additive approach)

No →

GreenScreen® tool is based on this
Classification of a Mixture Based on its Components

• To assign an overall benchmark for a mixture, it is necessary to identify ingredient substances of the mixture in addition to their concentrations and CLP classifications for each hazard endpoint.

• Classification of a mixture is based on concentration thresholds which require using Cut-Off Limits (limits of concern) and a Generic Concentration Limit (GCL) which triggers the classification
  – **Cut-off value**: are the minimum concentrations for a substance to be taken into account for classification purposes.
  – **Generic Concentration limits (GCL)**: are the minimum concentrations for a substance which trigger the classification of a mixture if exceeded by the individual concentration or the sum of concentrations of relevant substances

• There are two different concepts about how a substance contributes to the classification of a mixture under CLP criteria: the Additive Approach and Non-Additive Approach
CLP Mixture Rules for Each Hazard Endpoint + GreenScreen Scoring

<table>
<thead>
<tr>
<th>Non-additive</th>
<th>Additive</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Carcinogenicity (C)</td>
<td>• Acute Mammalian Toxicity (AT) (additivity formula)</td>
</tr>
<tr>
<td>• Mutagenicity/Genotoxicity (M)</td>
<td>• Skin Irritation (IrS)</td>
</tr>
<tr>
<td>• Reproductive Toxicity (R)</td>
<td>• Eye Irritation (IrE)</td>
</tr>
<tr>
<td>• Developmental Toxicity (D)</td>
<td>• Acute Aquatic Toxicity (AA)</td>
</tr>
<tr>
<td>• Endocrine Toxicity (E)</td>
<td>• Chronic Aquatic Toxicity (CA)</td>
</tr>
<tr>
<td>• Systemic Toxicity/Organ Effects (ST)(Single Exposure)</td>
<td>• Persistence (P)</td>
</tr>
<tr>
<td>• Systemic Toxicity/Organ Effects (ST)(Repeated Exposure)</td>
<td>• Bioaccumulation (B)</td>
</tr>
<tr>
<td>• Neurotoxicity (N) (Single Exposure)</td>
<td></td>
</tr>
<tr>
<td>• Neurotoxicity (N) (Repeated Exposure)</td>
<td></td>
</tr>
<tr>
<td>• Skin Sensitization (SnS)</td>
<td></td>
</tr>
<tr>
<td>• Respiratory Sensitization (SnR)</td>
<td></td>
</tr>
<tr>
<td>• Reactivity (Rx)</td>
<td></td>
</tr>
<tr>
<td>• Flammability (F)</td>
<td></td>
</tr>
</tbody>
</table>

In the **Additive Approach**, concentrations of ingredients with the same hazard are added together:
- if the sum of the concentrations of one or several classified substances in the mixture equals or exceeds the a generic concentration limit (GCL) set out for this hazard class/category, the mixture is classified for that hazard.

Under the **Non-Additive Approach**, if a mixture contains two chemicals, each below the GCLs defined for that hazard class, even if the sum of the two chemicals is above the limit, the mixture will not be classified.
Assessing Hazards from Mixtures of Chemicals

Snapshot of the ToxServices’ Mixture Tool

<table>
<thead>
<tr>
<th>Component</th>
<th>Chemical Name</th>
<th>CAS No.</th>
<th>Ingredient No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td></td>
<td>123456</td>
<td>1</td>
</tr>
<tr>
<td>Liquid</td>
<td></td>
<td>67890</td>
<td>2</td>
</tr>
<tr>
<td>Solid</td>
<td></td>
<td>111111</td>
<td>3</td>
</tr>
</tbody>
</table>

**Data input worksheet:** Each row represents one component of the mixture.

**GreenScreen® hazard scores for the 18 endpoints for the product mixture**

**Final Benchmark hazard score for the product mixture**

**Tool consists of three worksheets:**
- Data input
- Data output
- ATE calculation
GreenScreen hazard classification of High (H) for Reproductive Toxicity corresponds to CLP Category 1A/1B classification

- If the final mixture contains at least one ingredient that is present in the mixture at \( \geq 0.3\% \) and has a GreenScreen hazard classification of High (classified to GHS Category 1A or 1B)

GreenScreen hazard classification of Moderate (M) corresponds to CLP Category 2 classification

- If the final mixture contains at least one ingredient that is present in the mixture at \( \geq 3.0\% \) and has a GreenScreen hazard classification of Moderate (classified to GHS Category 2 for this endpoint).

<table>
<thead>
<tr>
<th>Ingredient Classified as:</th>
<th>Cut-off/concentration limits triggering classification of a mixture as:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Category 1 reproductive toxicant</td>
</tr>
<tr>
<td></td>
<td>Category 1A</td>
</tr>
<tr>
<td></td>
<td>( \geq 0.3% )</td>
</tr>
<tr>
<td></td>
<td>Category 1B</td>
</tr>
<tr>
<td></td>
<td>( \geq 0.3% )</td>
</tr>
<tr>
<td>Category 1A</td>
<td>( \geq 0.3% )</td>
</tr>
<tr>
<td>Category 1B</td>
<td>( \geq 0.3% )</td>
</tr>
<tr>
<td>Category 2 Carcinogen</td>
<td>( \geq 0.1% ) [Note 1]</td>
</tr>
<tr>
<td></td>
<td>( \geq 3.0% ) [Note 2]</td>
</tr>
</tbody>
</table>

Note 1: If a Category 2 reproductive toxicant ingredient is present in the mixture at a concentration between 0.1% and 3.0%, every regulatory authority would require information on the SDS for that product. However a label warning would be optimal.

Note 2: If a Category 2 reproductive toxicant ingredient is present in the mixture at a concentration of \( \geq 3\% \), both an SDS and a label would generally be expected.

Reproduced from GHS Table 3.7.1
Example: Calculating Overall Mixture Hazard Classification for Reproductive Toxicity

The mixture was classified as Low (L) for reproductive toxicity based on not meeting the criteria for Moderate scoring.

Although the mixture contains one ingredient (CAS# 3) with a Moderate (M) classification for reproductive toxicity, it is present below the threshold set for Moderate (3%) and is not considered in the final Benchmark score.

The mixture was assigned an overall Benchmark score of 4.
To date, approximately 20% of GreenScreened chemicals are classified as Benchmark 1 chemicals:
- Many of these are CMRs/PBTs and total >150 chemicals

A project with the Univ. of Mass-Lowell is underway to assess the chemical structures of Benchmark 1 chemicals in order to create an overall Benchmark 1 composite structure.
In toxicology, the Ashby and Tennant composite structure for genotoxic alerts is well-known

- Easily depicts potential genotoxins, and is useful for carcinogenicity prediction.

The 148 chemicals currently classified as BM-1 chemicals come from numerous chemical classes

- In a manner similar to Ashby and Tennant, the BM-1 structural alert project will identify an overall structure useful for predicting significant human health and environmental hazards.
- Such a structure would be helpful during the chemical formulation process and easily flag potential problems.

Ashby and Tennant (1988, 1989)
Conclusions

• The GreenScreen continues to evolve in order to incorporate best practices associated with assessing human health and environmental hazards

• Work is underway to incorporate mixtures assessment rules into the GreenScreen Inspector™, which is a freely available tool
  – Peer review of the tool is expected to take 8-12 months

• Future action items:
  – Securing on-going funding to make the >700 GreenScreens publicly accessible

Thank you!

mwhittaker@toxservices.com