GreenWERCS™

# Driving Innovation *for* Greener Chemistry

The Wercs®

Worldwide Environmental Regulatory Compliance Systems

# Agenda - what we hope to answer

- What is green chemistry?
- What is driving greener chemistry?
- What are the implications of green chemistry?
- What are organizations doing about it?
- How can formulation analytics provide greater insight?
- What are some success stories?

# Green Chemistry

- **Green chemistry** is the science behind bringing sustainability into chemical products and processes.
- The concept has gained traction in scientific and industrial chemical circles, leading to research and implementation and production based on the Twelve Principles framework.
- The Twelve Principles of **Green Chemistry** were first defined in the mid-1990s by Paul Anastas and John Warner.
  - The first to look comprehensively at the chemical life cycle and to think step by step about how to make each part of the process more sustainable.

"There is a tsunami of green chemistry sweeping our industry. Apart from reducing the environmental burden of a chemical process, there are some compelling reasons for using green chemistry, including improvements to margins, savings in processing costs, and even competitive advantage."

-Robert Peoples, *director at the American Chemistry Society's Green Chemistry Institute (GCI)*

# Situation – Human Health

- Chemicals are pervasive in today's environment with over 80,000 chemical CAS#'s on record.
- Increase in childhood disease and birth defects has skyrocketed over the past three decades.

# Situation – Environment

- Increased public awareness of hazard in chemical-containing products.
- Concerns have grown exponentially.
- Consumers demanding transparency/disclosure.

# Influence of Social Media is Driving Public Awareness

Social media “is only going to become more pervasive” and, as such, become a critical factor in the success or failure of any business.


# Public Awareness/Perception Drives New Legislation

- NGO's–Reporting manufacturers/retailers–not responding to regulations and public concern.

- Increased publicity drives governments/creates new laws–both sides forced to improve business practices.
  - Asbestos
  - BPA
  - Bath Salts
  - Sunscreen
  - Pthalates




# Increased Enforcement

## EPA Announces 2010 Enforcement and Compliance Results

EPA's criminal enforcement program opened 346 new environmental crime cases in FY 2010. These cases led to 289 defendants charged for allegedly committing environmental crimes, the largest number in five years, 198 criminals convicted and $41 million assessed in fines and restitution.

May 4, 2010

### Wal-Mart to Pay $27.6 Million for Environmental Violations in California

### EPA Chemical Enforcement Focuses on Nanoscale Materials Manufacturers

Posted on April 6, 2010 by Lynn L. Bergeson

### State fines Chemical Waste Management for PCBs

TAGS: Environment | Environment and nature | Government and politics | State governments | Waste management

By The Associated Press 05/20/11 6:46 PM

The Associated Press

SHARE PRINT

### DuPont to pay $3.3m in chemical fines

EPA concludes failure to disclose test results breaches Toxic Substances Control Act

washingtonpost.com > Metro > Virginia

### Mining Giant to Pay $20 Million EPA Fine

Runoff Polluted Waters in W.Va., Ky.

## EXAMPLES

- BPA
- PBDEs
- PFC’s
- Phthalates
- Glymes
- Bath Salts
- ???

# Risk of Ignoring Green Chemistry

- Brand damage
  Johnson & Johnson (formaldehyde)

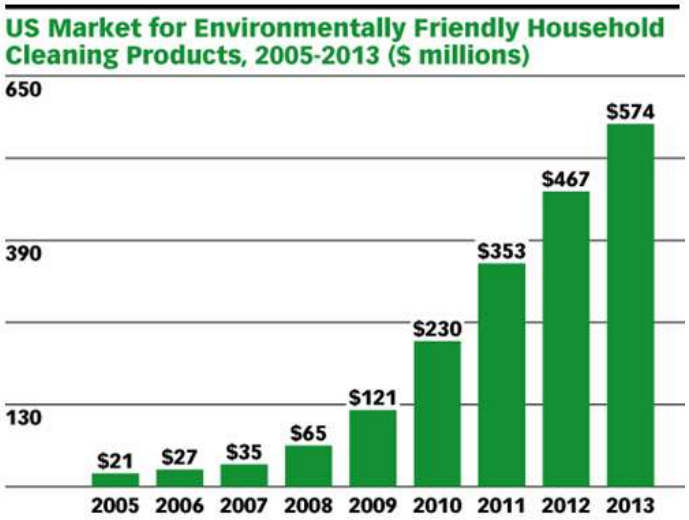
- Product recalls
  Enormous expense

- Loss of sales growth opportunities
  - Retailers
  - State agencies
  - Green chemistry requirement

- Cost of reactive R&D efforts

# Benefits of Embracing Green Chemistry

- Competitive advantage—marketing safer, “Greener” products
- Cost and liability reduction
  - Handling, shipping, toxic chemicals for disposal and reverse logistics of toxic materials
  - Insurance costs
- Brand protection—reduce risk of brand erosion
- Productivity—employee illness
- Trust—increase amongst consumer, employees, communities and investors




"…In fact, green chemistry has gone from blackboard conjecture to a multimillion dollar business in the past 15 years."

-Mary Ellen Weber, *EPA*

## *Case Studies:*

Clorox Green Works Brand

$40 million market share 1st year

Seventh Generation

1 million 1999, 150 million 2010 – Significant % growth 10 years

# Risks of Greenwashing

## FTC Moves May Signal Start of 'Greenwashing' Crackdown

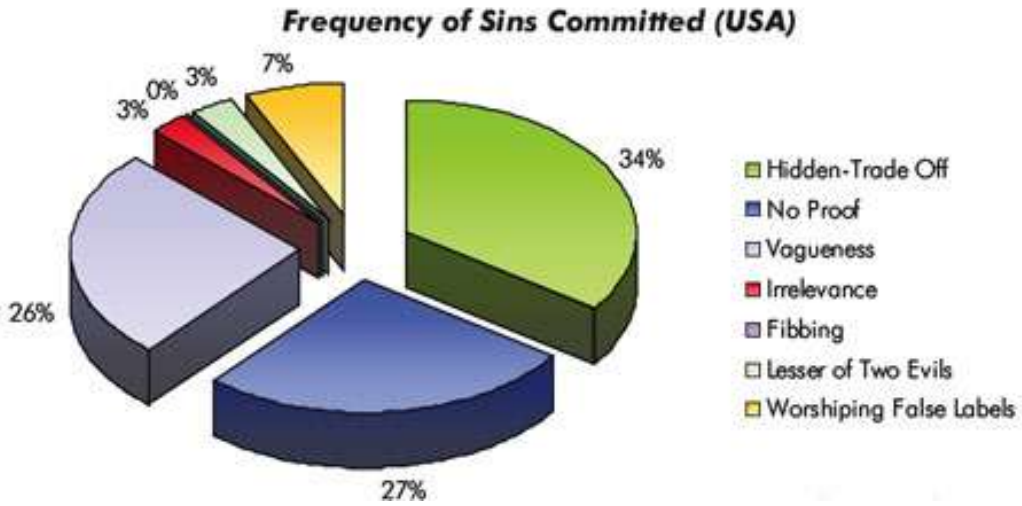
By GABRIEL NELSON of Greenwire
Published: February 3, 2010

The Federal Trade Commission is expected to crack down on "greenwashing" when it updates its environmental marketing guidelines for the first time since 1998.


1. FTC has enforcement authority to issue a cease and desist order for up to 20 years
2. Potential for FTC to prohibit "deceptive" claims against companies entire product line
3. Terms of consent order can follow significant management to other jobs

# Risks of Greenwashing

## Agency Seeks to Tighten Rules for 'Green' Labeling





The Seven Sins of Greenwashing—as compiled by **TerraChoice Environmental Marketing**

# Your products are being scrutinized…

1. Chemicals are impacting human health.
2. Chemicals are impacting the environment.
3. Influencing power of social media on public perception.
4. Public perception forces legislation.
5. Enforcement ($) follows legislation.
6. Ignoring “Green Chemistry” has risks.
7. Embracing “Greener Chemistry” has benefits.
8. Faking it (Greenwashing)…has consequences.
9. **Early anticipation of “Chemicals of Concern” is critical.**
10. **“Reactive Substitution” is expensive.**
11. **Software/Automation/Tools are critical.**

# GreenWERCS™: (grēn-wûrks)

*n.* Software tool that :

1. ***A highly automated tool to determine the "Green"-ness of chemical based products.***
2. ***A software tool that leverages transparent and configurable scoring methodologies to calculate the overall impact of chemicals to human health, and the environment.***
3. ***Allows proactive businesses to save time and money by providing a view into potential regulatory changes.***

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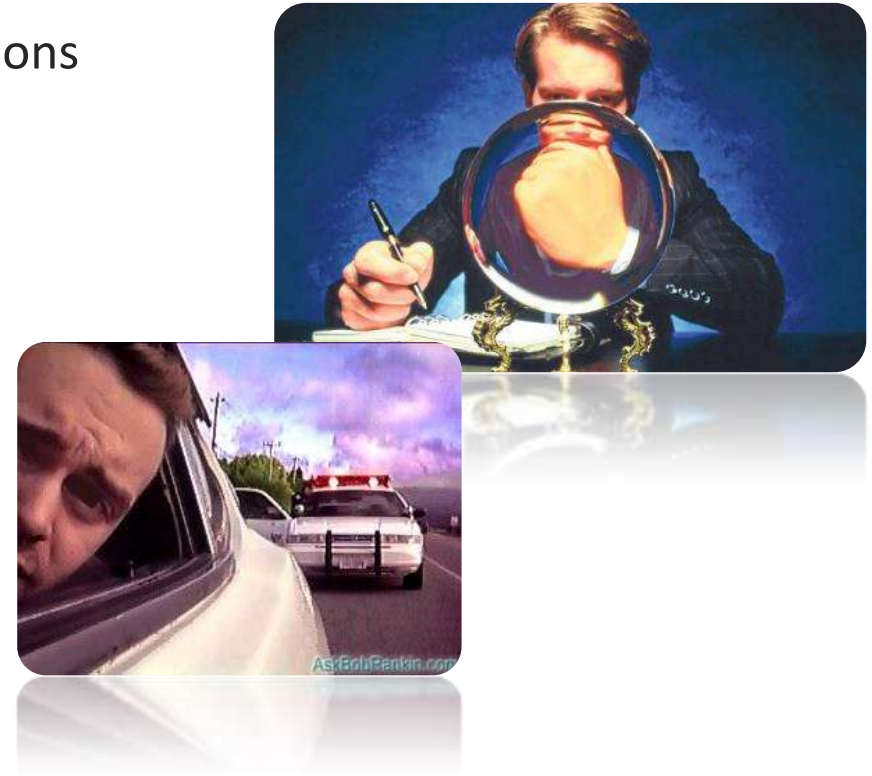
# GreenWERCS™ approach

- Anticipate future regulations
  - Avoid multiple chemical substitutions
  - Avoid transition costs
- Transparency
  - Measurable
  - Dependable
  - Science-based data
- Avoid greenwashing

  Eliminate potential accusations



# How does it work?

- Evaluate a single product or a group of products.
- Uses the formulation of the selected product.
- Uses regulatory lists or ‘Internal’ regulations.
- Applies calculation method against formulation and selected regulations.
- Multiple ‘models’ support different mixes of regulations and scoring settings.

My WERCS Authoring Management Distribution System Window Help

The Wercs

Green WERCS - Home

GreenWERCS

Home | Scoring Models | Axis Groups | Categories | Scoring | Advanced Scoring | Analytics

## Home Green WERCS

### Getting Started

- Design a new scoring model
- Manage Axis Group
- Manage Categories
- Review/revise an existing scoring model

Ned Matrix

### Scoring Products

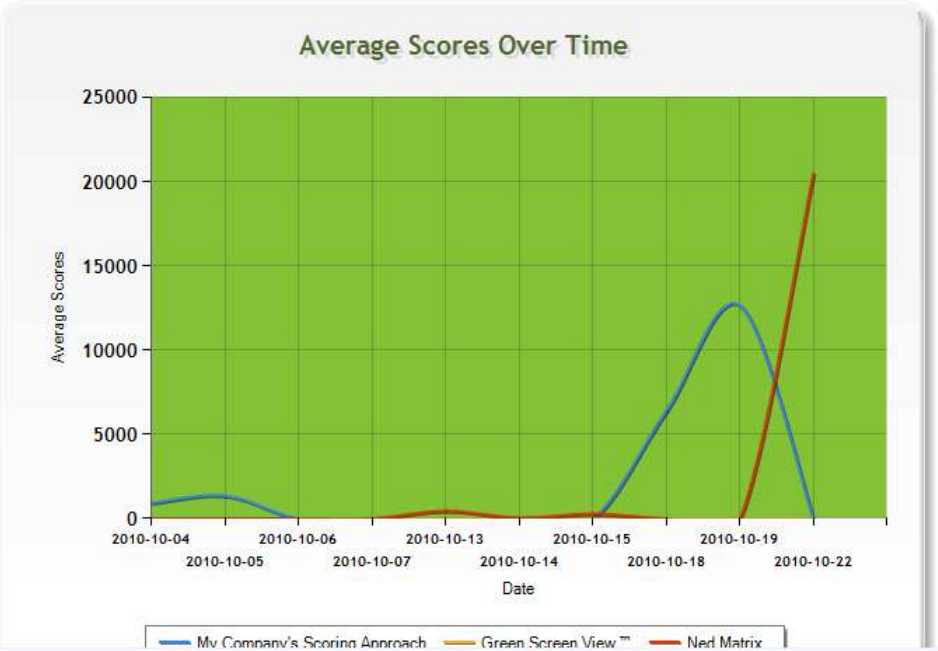
- Score Individual Product(s) Max. 6
- Score Product Group based on a attribute
- Analyze historical scores

### Date Range for charts

All | This Year | This Month

Show Charts

### Average Scores Over Time

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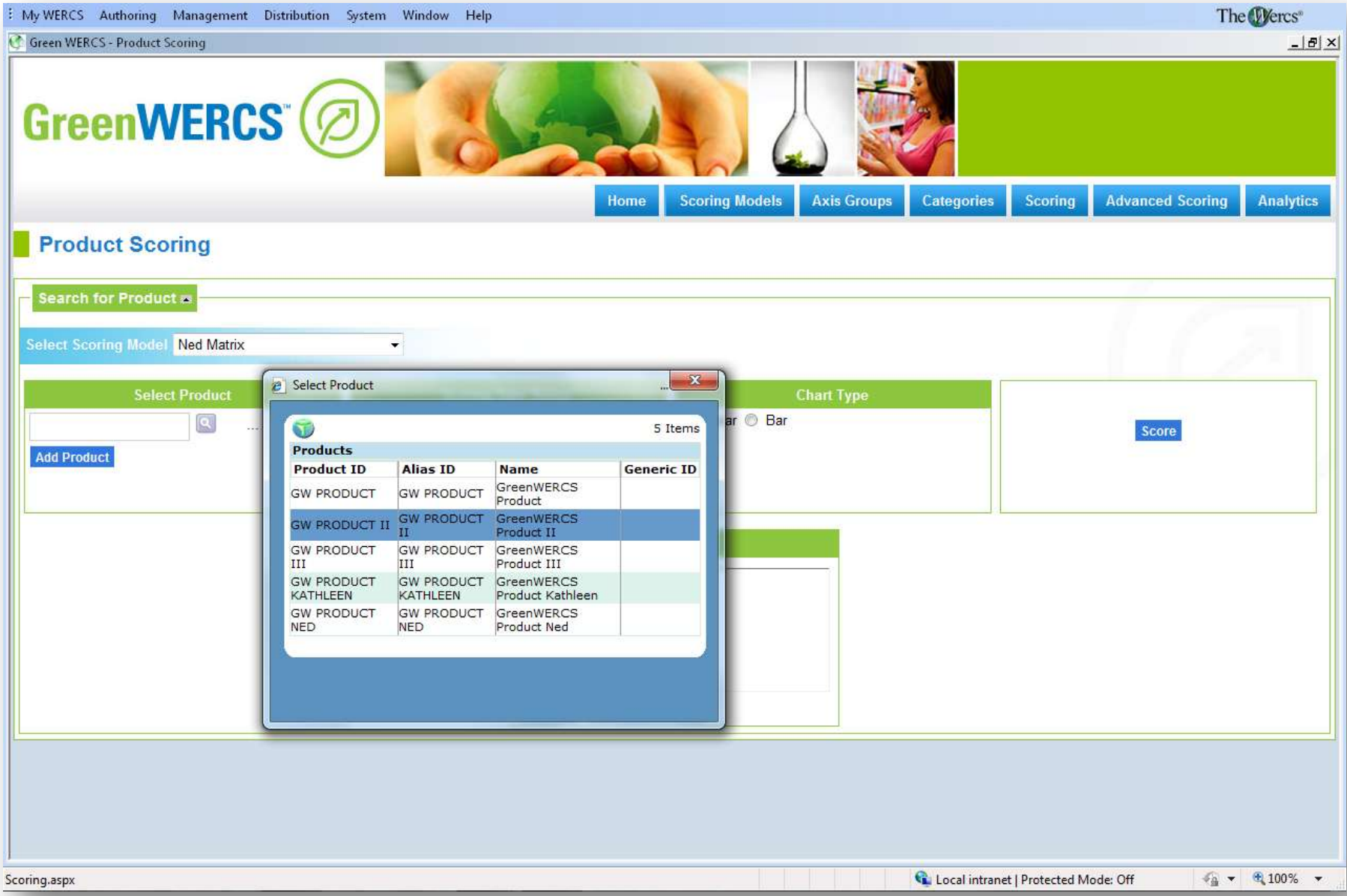
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Green WERCS - Product Scoring
GreenWERCS
Home
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Axis Groups
Categories
Scoring
Advanced Scoring
Analytics
Product Scoring
Search for Product
Select Scoring Model
Ned Matrix
Select Product
Add Product
Chart Type
Bar
Score
Select Product
5 Items
Products
Product ID
Alias ID
Name
Generic ID
GW PRODUCT
GW PRODUCT
GreenWERCS Product
GW PRODUCT II
GW PRODUCT II
GreenWERCS Product II
GW PRODUCT III
GW PRODUCT III
GreenWERCS Product III
GW PRODUCT KATHLEEN
GW PRODUCT KATHLEEN
GreenWERCS Product Kathleen
GW PRODUCT NED
GW PRODUCT NED
GreenWERCS Product Ned
Scoring.aspx
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The Wercs

Green WERCS - Product Scoring

Clear All | Remove Selected

**Total Score [GW PRODUCT] 19180**

Bar Graph | Radar Graph | Comparison Graph

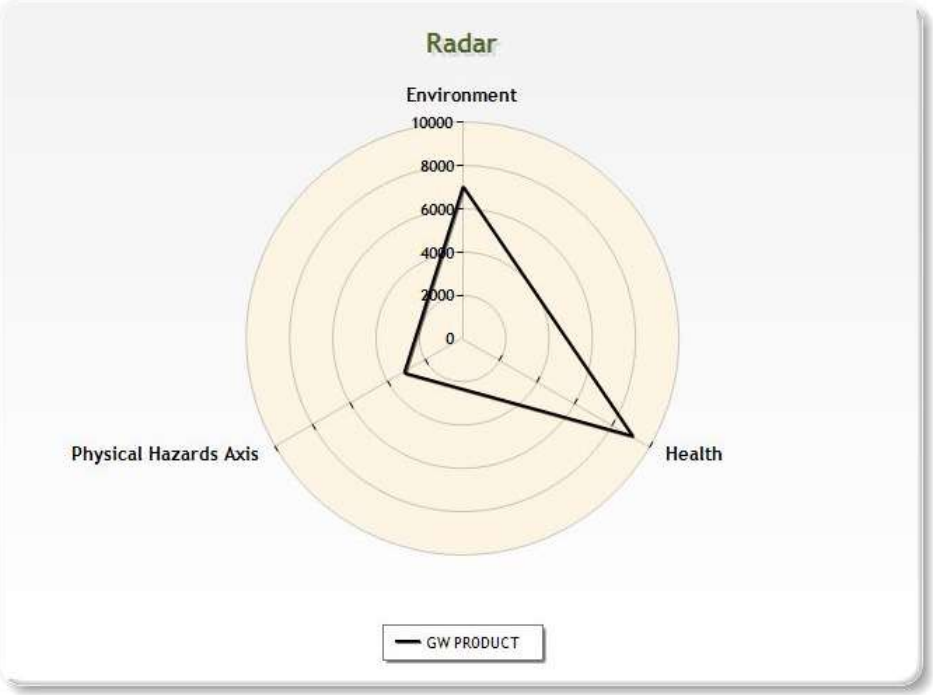


Chart Type: Line

Done

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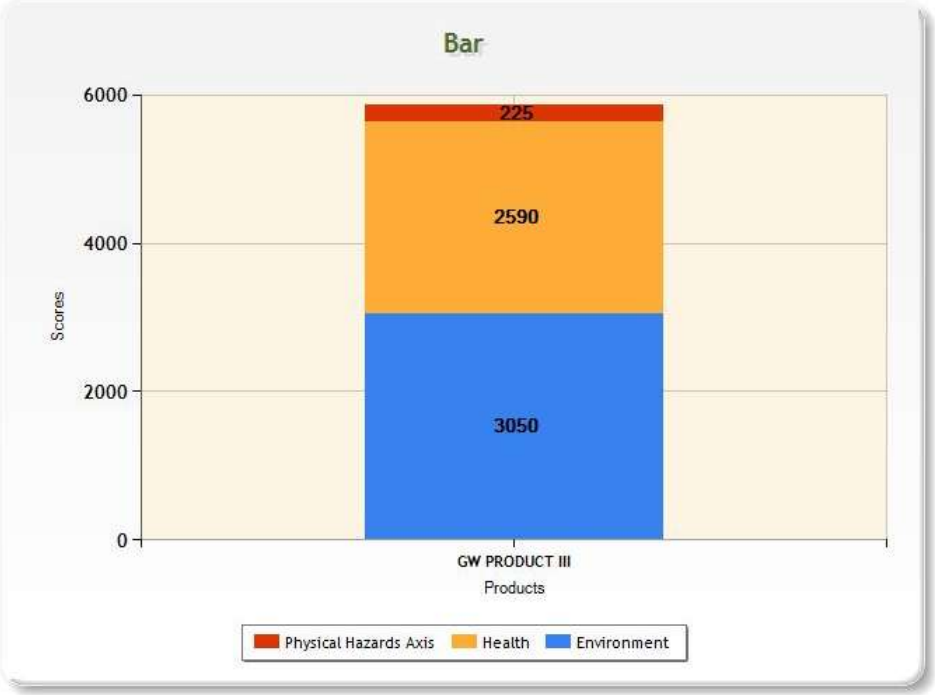
The WERCS

Green WERCS - Product Scoring

Clear All Remove Selected

Total Score [GW PRODUCT III] 5865

Bar Graph | Radar Graph | Comparison Graph

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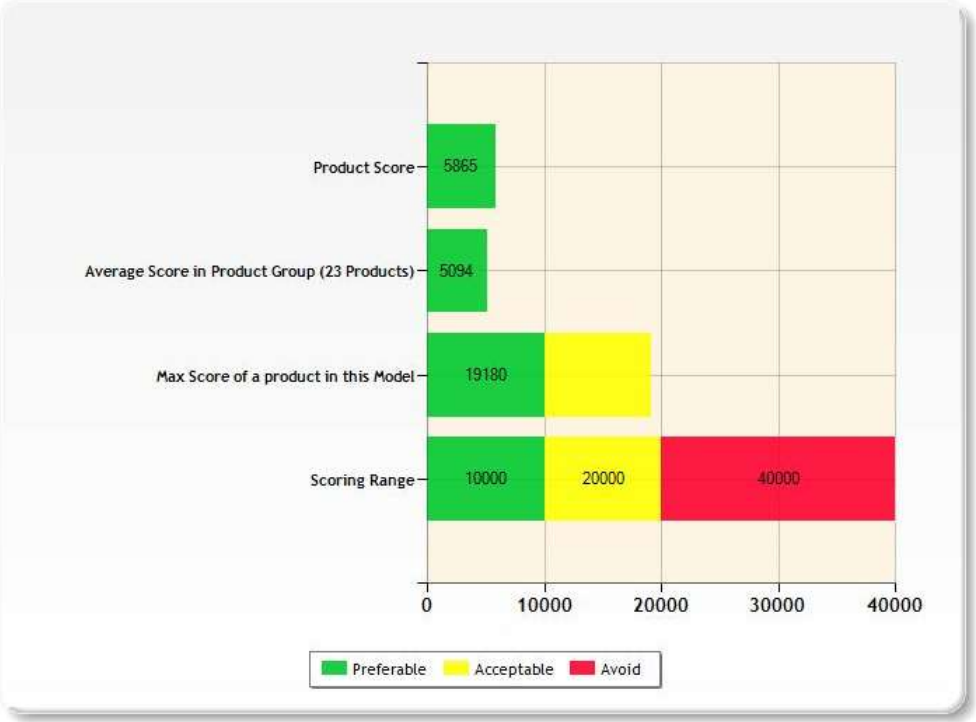
My WERCS Authoring Management Distribution System Window Help

Green WERCS - Product Scoring

Clear All Remove Selected

Total Score [GW PRODUCT III] 5865

Bar Graph | Radar Graph | Comparison Graph

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Green WERCS - Produc... | Reform of Toxic Chemical... | Page | Safety | Tools

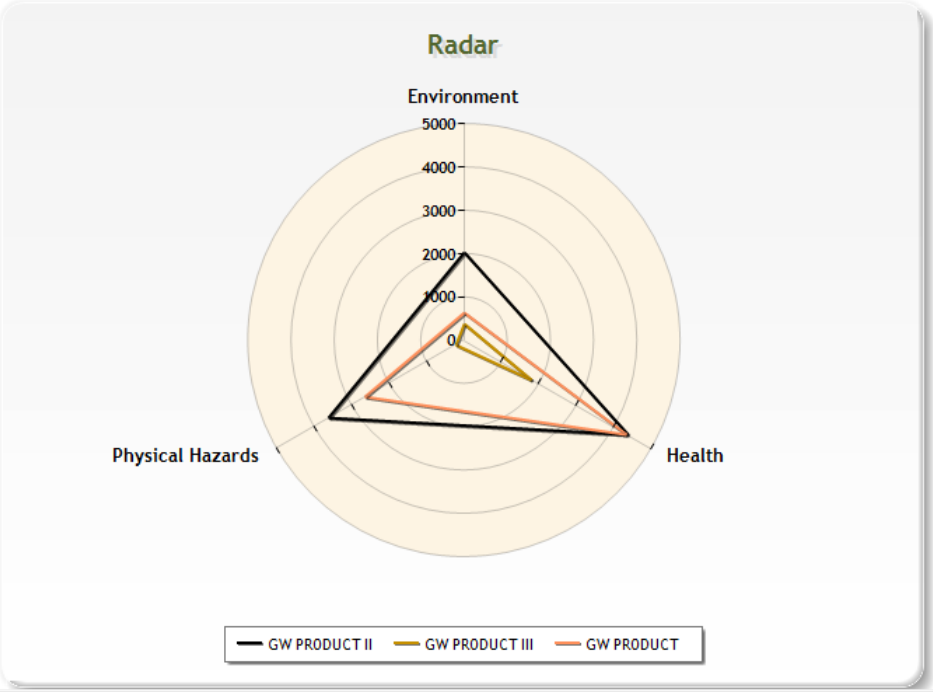
**Products**

GW PRODUCT II
GW PRODUCT III
GW PRODUCT

Clear All | Remove Selected

**Total Score [GW PRODUCT] 7610**

Bar Graph | Radar Chart

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Green WERCS - Produc... | Reform of Toxic Chemical... | Page | Safety | Tools

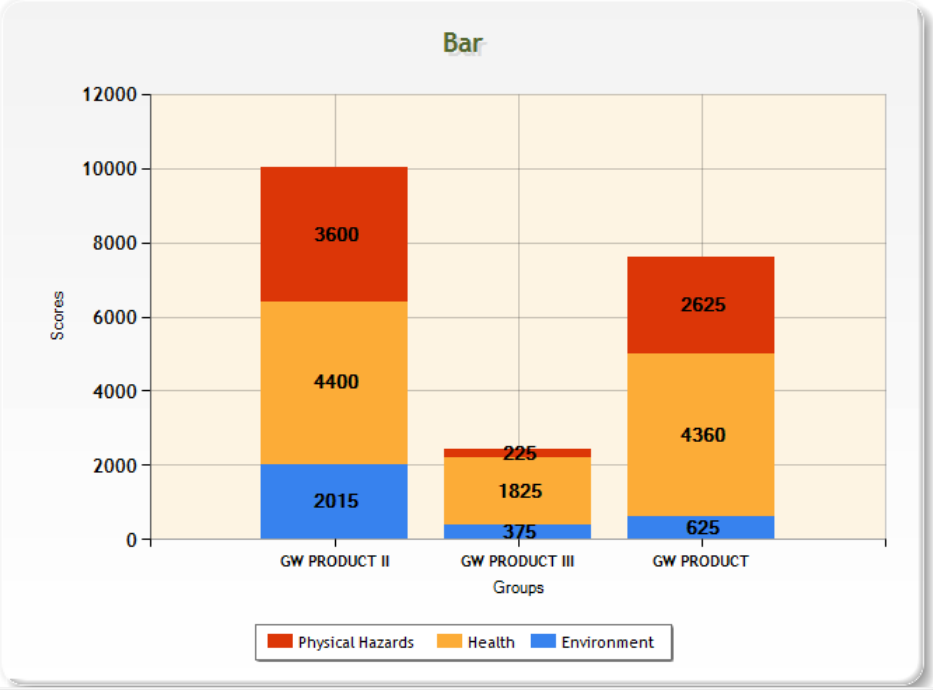
**Products**

GW PRODUCT II
GW PRODUCT III
GW PRODUCT

Clear All | Remove Selected

## Total Score [GW PRODUCT] 7610

Bar Graph | Radar Chart

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The WERCS

Green WERCS - Advanced Scoring

GreenWERCS

Home | Scoring Models | Axis Groups | Categories | Scoring | Advanced Scoring | Analytics

## Attribute-based Scoring

**Select Scoring Model**

Ned Matrix

**Select attribute for advanced scoring search criteria**

RU

Update

**Override X - Y Axis Configuration**

**Identified uses**

Nematicide
Organic solvent for the electronics industry
Packaging
Personal care
Pesticide
Pharmaceutical
Photographic chemical
Pigment
Plant protection agent
Plasticiser for PVC
Polyaminoamide
Polymer additive

Clear Selection Submit

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Green WERCS - Advanced Scoring

GreenWERCS

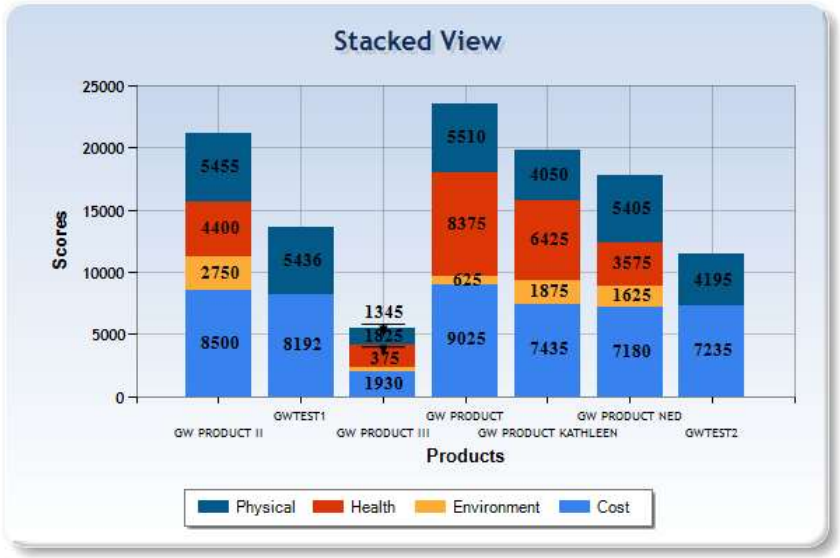
Home | Scoring Models | Axis Groups | Categories | Scoring | Advanced Scoring | Analytics

## Attribute-based Scoring

**VIEW:**

***Ned Matrix***

Default View | Stacked View




**Highlights - Products: 7**

**Best Scored Product**

GreenWERCS Product II (0,0)

**Worst Scored Product**

GreenWERCS Product II (0,0)

**Score Details**

**Health**

Known Carcinogens Reproductive and Development Hazard Mutagenic Hazard Suspected Carcinogens Endocrine Disruptors

**Environment**

**Physical**

**Cost**

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GreenWERCS™

# *Scoring Model Architecture – Overview (One Time Setup)*

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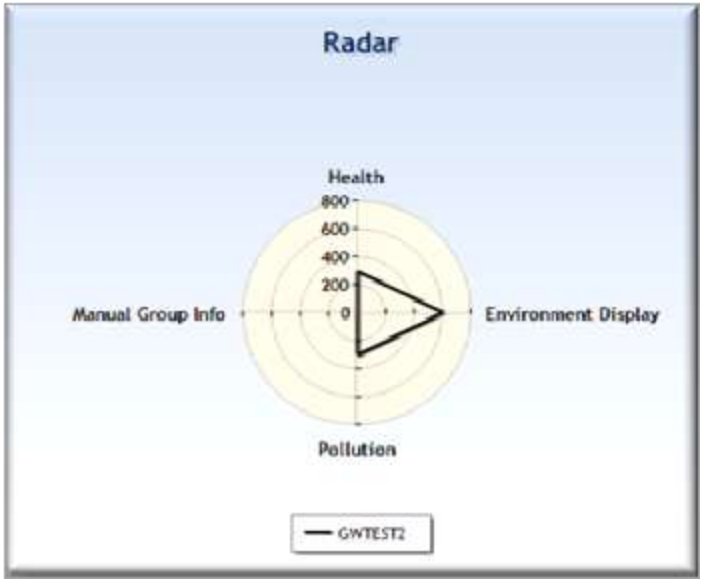
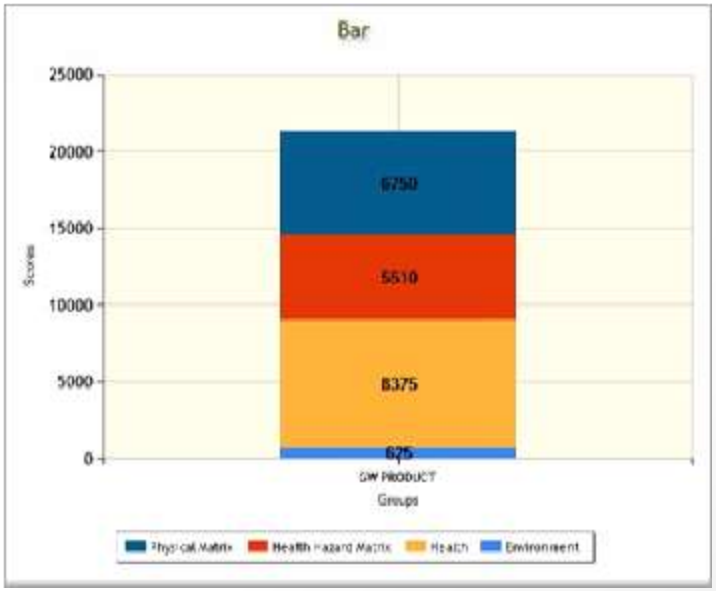
## Scoring Model




## Groups

- Health
- Environment
- Manual Group–i.e. Cost
- Pollution

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The WERCS

Green WERCS - Manage Members

GreenWERCS

Home | Scoring Models | Axis Groups | Categories | Scoring | Advanced Scoring | Analytics

## Manage Members

**Category**

***Hazardous Air Pollutants***

**Filter by Name**

air pollution

Show Clear

**Member Lists**

| Add? | List Name |
|---|---|
| ☐ | Canada - Ontario - Air Pollution - Local Air Quality - Guidelines |
| ☐ | Canada - Ontario - Air Pollution - Local Air Quality - Schedule 2 |
| ☐ | Canada - Ontario - Air Pollution - Local Air Quality - Schedule 3 |
| ☐ | Canada - Ontario - Air Pollution - Local Air Quality - Schedule 6 |
| Added | EU - Air Pollution (2001/379/EC) - Heavy Metal Pollutants |
| Added | EU - Air Pollution (2004/107/EC) - Ambient Air Target Values |
| Added | EU - Air Pollution (2004/107/EC) - Substances Subject to Monitoring Requirements (Article 4) |
| Added | EU - Air Pollution (2004/107/EC) - Upper and Lower Assessment Thresholds |
| ☐ | Japan - Air Pollution Control Law - Designated Particulates |
| ☐ | Japan - Air Pollution Control Law - Designated Substances |

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Save Back to Category

Done

Local intranet | Protected Mode: Off 100%

MSN.com | Green WERCS - Produc... | Page | Safety | Tools

GreenWERCS

Home | Scoring Models | Axis Groups | Categories | Scoring | Advanced Scoring | Analytics

## Product Scoring

Search for Product

Products

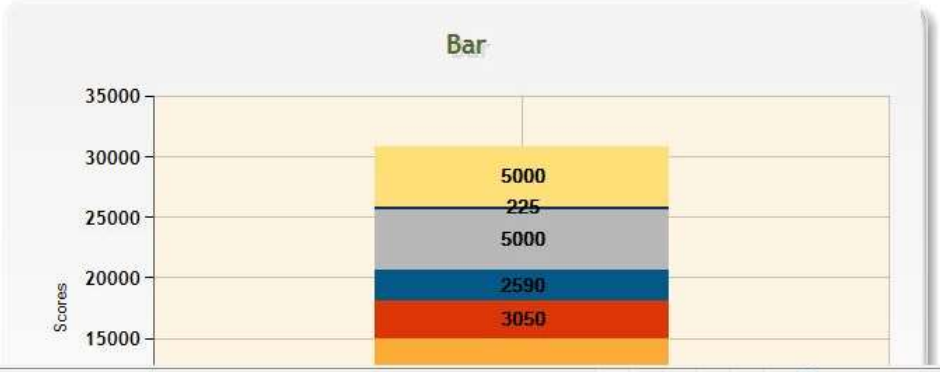
GW PRODUCT III

Clear All | Remove Selected

Product Summary Document

Total Score [GW PRODUCT III] 30865

Bar Graph | Radar Graph | Comparison Graph

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GreenWERCS



Home | Scoring Models | Axis Groups | Categories | Scoring | Advanced Scoring | Analytics

## Export Data

**Select Scoring Model**

Ned Matrix

**Date from**

12/01/2010

**Date to**

02/03/2011

December 2010

| Su | Mo | Tu | We | Th | Fr | Sa |
|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 26 | 27 | 28 | 29 | 30 | 31 | |

**Display**

Total Only | Historical Scores | Score D

Generate Report | Export Data

| Product | ore | Date |
|---|---|---|
| GW PRODUCT | 1800 | 2011-Jan-28 4:20:12 PM |
| GW PRODUCT KATHLEEN | 220 | 2010-Dec-10 8:44:34 AM |
| GW PRODUCT NED | 0500 | 2011-Jan-28 4:28:38 PM |
| COFFEE CLEAN | 0 | 2011-Feb-03 1:12:05 PM |
| GW PRODUCT III | 30865 | 2011-Jan-28 3:27:01 PM |
| A00064 | 125 | 2010-Nov-29 8:54:46 AM |
| GW PRODUCT II | 167250 | 2011-Jan-31 9:25:54 AM |

GreenWERCS





## Export Data

**Select Scoring Model**: Ned Matrix

**Date from**: 12/01/2010

**Date to**: 02/03/2011

**Display**

○ Total Only ○ Historical Scores ◉ Score Details ○ Group Totals

Generate Report | Export Data

| Product | Score | (1) Health | (3) Environment | (61) Cost | (122) Physical Hazards Axis | (241) Packaging Score | (301) Water Usage | (321) Energy Usage | (1) Known Carcinogens | (1) Reproductive and Development Hazard | (1) M |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GW PRODUCT | 49180 | 9055 | 7000 | 10000 | 3125 | 5000 | 10000 | 5000 | 1375 | 1500 | 0 |
| GW PRODUCT KATHLEEN | 15220 | 6845 | 5600 | 0 | 2775 | 0 | 0 | 0 | 1925 | 0 | 0 |
| GW PRODUCT NED | 15050 | 5200 | 4750 | 0 | 5100 | 0 | 0 | 0 | 3575 | 0 | 0 |
| COFFEE CLEAN | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| GW PRODUCT III | 30865 | 2590 | 3050 | 5000 | 225 | 5000 | 5000 | 10000 | 825 | 0 | 0 |
| A00064 | 125 | 55 | 70 | 0 | 0 | 0 | 0 | 0 | 55 | 0 | 0 |

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Green WERCS - Export Data

GreenWERCS



Home | Scoring Models | Axis Groups | Categories | Scoring | Advanced Scoring | Analytics

## Export Data

**Select Scoring Model**

Ned Matrix

**Date from**

12/01/2010

**Date to**

12/14/2010

**Display**

○ Total Only ○ Group Details ○ Score Details ◉ Group Totals

Generate Report | Export Data

| Product | Total Score | (1) Group Name | (1) Score | (3) Group Name | (3) Score | (121) Group Name | (121) Score | (122) Group Name | (122) Score | (161) Group Name | (161) Score | Date |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A00064 | 70 | | | Environment | 70 | | | | | | | 2010-Dec-02 1:45:57 PM |
| COFFEE CLEAN | 0 | | | | | Health Hazard Matrix | 0 | | | | | 2010-Dec-10 8:49:14 AM |
| GW PRODUCT | 9900 | | | | | | | | | Environmental Matrix | 9900 | 2010-Dec-08 5:13:08 PM |
| GW PRODUCT II | 11460 | | | Environment | 5600 | Health Hazard Matrix | 5860 | | | | | 2010-Dec-09 8:53:25 AM |
| GW PRODUCT III | 3880 | Health | 1200 | Environment | 1000 | | | | | Environmental Matrix | 1680 | 2010-Dec-09 9:13:20 AM |
| GW PRODUCT KATHLEEN | 29500 | Health | 6845 | Environment | 5600 | Health Hazard Matrix | 6120 | Physical Harards | 2775 | Environmental Matrix | 8160 | 2010-Dec-10 8:44:34 AM |

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# Case Study

## Who is Allergan?

Founded in 1950

Developed the first antihistamine eye drops

Today 4.8 Billion dollar global multi-specialty healthcare company

Portfolios of products: eye care, neuroscience, medical dermatology, medical aesthetics, obesity intervention and urologic.

## What were the Challenges/Drivers?

Internal interest in method for demonstrating the safety of their products.

Desire to efficiently compare products to one another: measure safety and effectiveness.

Allergan's interest grew when they were exposed to Walmart's "Green Score"

First exposure to an automated tool that could quickly review products by category and provide meaningful information about chemical hazards.

## Journey/Discovery

The first phase to see products compared against one another and as groups.

Scoring their products provided immediate credibility to marketing and R&D.

They now had tangible reliable proof for marketing.

R&D and EHS have a better way to view and organize product formulations which enabled them to look for substitutions and greener alternatives.

# Case Study

## Lessons Learned/Beyond the Solution

The biggest win is ability to review all incipient ingredients against authoritative human health and environmental concerns.

Allergan configured the tool and they developed an Allergan scoring model.

Example: Additional insight regarding Boric Acid.

- Chemical appears on the SIN list and would need to be eliminated as an ingredient as a preservative.
- Working now on safer alternatives
- Sensitive to which alternatives have the potential to be regulated, saving significant amounts of money with new products and substitutions to existing products in a phase proactive approach.

This “Radar Detector” approach of proactively looking into the future is critical to the drug industry because of time to market and FDA approval processes.

Evaluating use of GreenWERCS for their in house developed API, leveraging testing and toxicological data they compile. This will help the R&D team develop safer products in the future.

# Case Study

GIGABASE循绿

## Who is GIGABASE?

GIGABASE is a China-based platform that ranks construction materials based on their ecological and health impact. Our master plan is to create market incentives for manufacturers to incrementally produce cleaner, healthier materials and transparently explain their impact.

## GIGABASE's Challenge

Our platform lives and dies with credibility. When our clients dig into the details, they expect to find transparent, trustable results. For us, this hinges on chemistry. Users want full disclosure analysis and transparency, though most are turned off by deep chemical information, formulations, and technical details. This process requires time and effort and is still subject to human error.

# Case Study

GIGABASE循绿

## Journey/Discovery Process

Initially, our chemists individually broke consumer products into parts, then chemical compounds, and finally into raw chemicals. Each step was then analyzed for health impact against 3 regulatory lists. Results were made into simple understandable graphics and were finally published. Best case scenario–our chemists were spending 2-3 weeks reviewing products.

## Solutions

For us, the Wercs offers a solution that both saves time while improving our credibility. Not only are our formulations reviewed against more regulatory lists than we thought existed, they are consistently reviewed each time, and are supported with simple graphics to communicate results and create leverage for improvement. The icing on the cake– we can re-evaluate formulations as often as we want, with updated vetted results just a click away.

# Case Study

HALLIBURTON

## Who is Halliburton?

Founded in 1919

Global leader providing products and services to the energy industry.

60,000+ global employees located in approximately 80 countries.

Formulate products used to extract oil, gas and other energy products.

## What were the Challenges/Drivers?

As formulators of specialized products for the energy industry, they were driven to develop a scoring approach for evaluating formulated products impact on human health, and the environment, as well as compare products to each other in a relative fashion

Approach must allow ability to quickly score and review raw materials they purchased

Numerically score and compare products against a GHS centric scoring framework

Provide transparence around the method they developed

# Case Study

HALLIBURTON

## Journey/Discovery

GreenWERCS software tool enabled Halliburton to accomplish 3 key goals. Initial focus was on eliminating products that had a high/bad scores.

Tool provided ability to look at product groups and make decisions to eliminate products where safer alternative existed.

Focus development of new products safer for the environment.

Reviewing raw materials, working with supply chain, R&D developed significantly safer products.

Example: being released is an actual food ingredient that goes into fracking fluids.

Obtain empirical data, science based, that assisted in marketing new greener products to customers.

## Lessons Learned/Beyond the Solution

The biggest thing learned was actually very simple.

After relatively unsuccessful efforts for years of trying to push green chemistry, GreenWERCS provided easy to understand information visually in front of people

Visual data changed internal dynamics

Significant shift in the thinking of major stakeholder occurred

They changed/improved over 20 key products that all were made greener. In addition, now they are much more engaged with their supply chain on new product chemistry and safer alternatives.

# Case Study


## What are Walmart's challenge s as it pertains specifically to chemically intensive products?

Walmart is on a sustainability journey that encompasses many aspects of sustainability. One of our goals as a company is to sell products that sustain people and the environment. Chemical products are diverse and the chemicals we sell range from motor oil to laundry detergent. Walmart's challenge is to take a closer look into these products and find ways to continuously improve the chemistry of the product while keeping cost and efficacy in mind.

## What was the primary driver for selecting/building GreenWERCS as a tool/solution?

With the sustainability vision in place, Walmart needed a way to look at the ingredients of a product that kept the suppliers chemical formulation safe, while still assessing detailed information. Fortunately for Walmart, we started using the WERCS tool in 2006. The WERCS tool collects formulation data from suppliers and provides Walmart with regulatory information. In 2008, the tool was chosen to begin analysis of the chemicals in another fashion; bouncing the ingredients of a product against a group of chemical lists that were chosen by Walmart's stakeholder group the Chemical Intensive Products Network, or CIP. Leveraging the information already gathered by WERCS, Walmart could see results from the lists of CMRs and PBTs chosen and a numerical score could be derived.

# Case Study


## What lessons learned or surprises have you learned since launching the tool internally?

Once the tool was turned on, Walmart had immediate access to the scoring of over 100,000 UPCs. While this is a wealth of information, we struggled with explaining the results of all of these product to our merchandise teams with clear direction and goals. At first we envisioned the buyers directly accessing the tool and having conversations with suppliers about the future of these products. We have learned that this is a powerful tool that needs to be used correctly, and in the hands of the wrong person there is the possibility of the results being incorrectly interpreted.

## How has the tool assisted in advancing safer or greener chemistry for Walmart, or supported a broader strategy?

When the tool was launched in 2009, it was immediately available for the suppliers to utilize. The suppliers are able to see their products and we have seen some action on their part to correct incorrect information and improve their ingredients, both improving their overall results. Having the GreenWERCS tool in place will be the cornerstone for assessing chemical products for chemical sustainability, and will be used alongside other important sustainability attributes for the broader Sustainability Index.

"Sustainability and lowering costs are totally aligned. We are looking at sustainability from a business standpoint–not from a standpoint of altruism. In fact, a lot of our suppliers are already way ahead of us when it comes to implementing sustainability."

-Lee Scott, *Walmart's chairman of the executive committee*

# Summary

- The needs for greener chemistry is increasing exponentially.
- The public and government bodies are holding corporations accountable.
- There is a need for a streamlined and automated approach to evaluating product chemistry.

# For More Information

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# 12 Principles of Green Chemistry

1. **Prevent** - It is better to prevent waste than to treat or clean up waste after it has been created.
2. **Atom Economy** - Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. **Less Hazardous Chemical Syntheses** - Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. **Designing Safer Chemicals** - Chemical products should be designed to effect their desired function while minimizing their toxicity.
5. **Safer Solvents and Auxiliaries** - The use of auxiliary substances (e.g., solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.
6. **Design for Energy Efficiency** - Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure.

# 12 Principles of Green Chemistry

7. **Use of Renewable Feedstocks** - A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
8. **Reduce Derivatives** - Unnecessary derivatization (use of blocking groups, protection/deprotection, temporary modification of physical/chemical processes) should be minimized or avoided if possible, because such steps require additional reagents and can generate waste.
9. **Catalysis** - Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. **Design for Degradation** - Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.
11. **Real-time analysis for Pollution Prevention** - Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. **Inherently Safer Chemistry for Accident Prevention** - Substances and the form of a substance used in a chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.