Toxics Use Reduction Institute

TUR Options Assessments: Tools that Planners Can Use

Pam Eliason, TURI
Mark Rossi, Clean Production Action

TURI's Fall 2010 Continuing Ed Conference
November 3, 2010
Norwood, MA

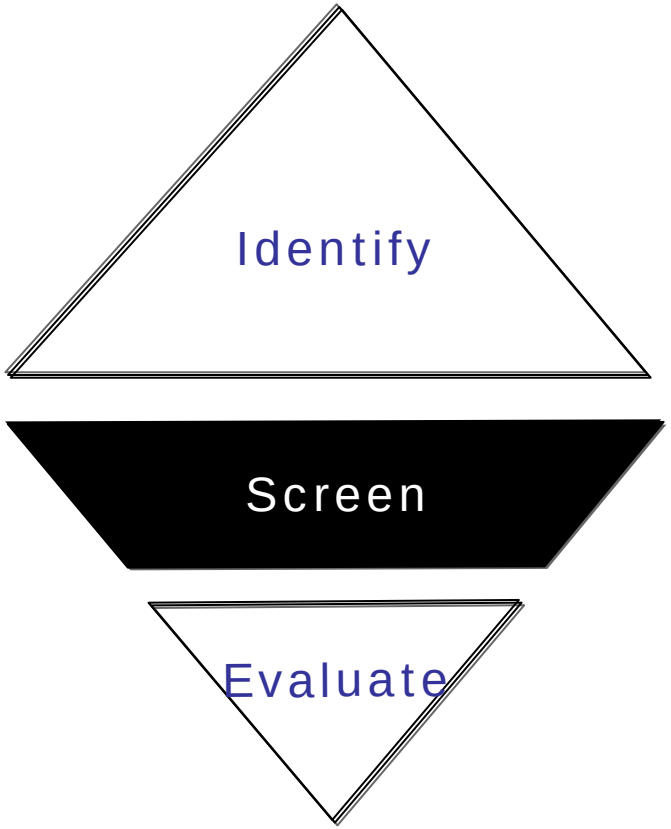
TURI
Toxics Use Reduction Institute
University of Massachusetts Lowell
One University Avenue
Lowell, Massachusetts 01854-2866
978.934.3275 fax: 978.934.3050
www.turi.org

What We'll Cover

- TUR Options Evaluation process
- Why consider if a substitution is safer
- Sources of information on chemicals
- Tools for comparing options
- Considerations when looking at different materials

TUR Option ID and Evaluation Process

For *each* toxic in *each* production unit,



Brainstorm TUR Options
- Use 6 TUR techniques
- Generate lots of ideas

Eliminate TUR Options
- Technically or economically infeasible
- Not TUR

Evaluate remaining TUR Options
- Technical evaluation
- Economic evaluation

But is it Safer?

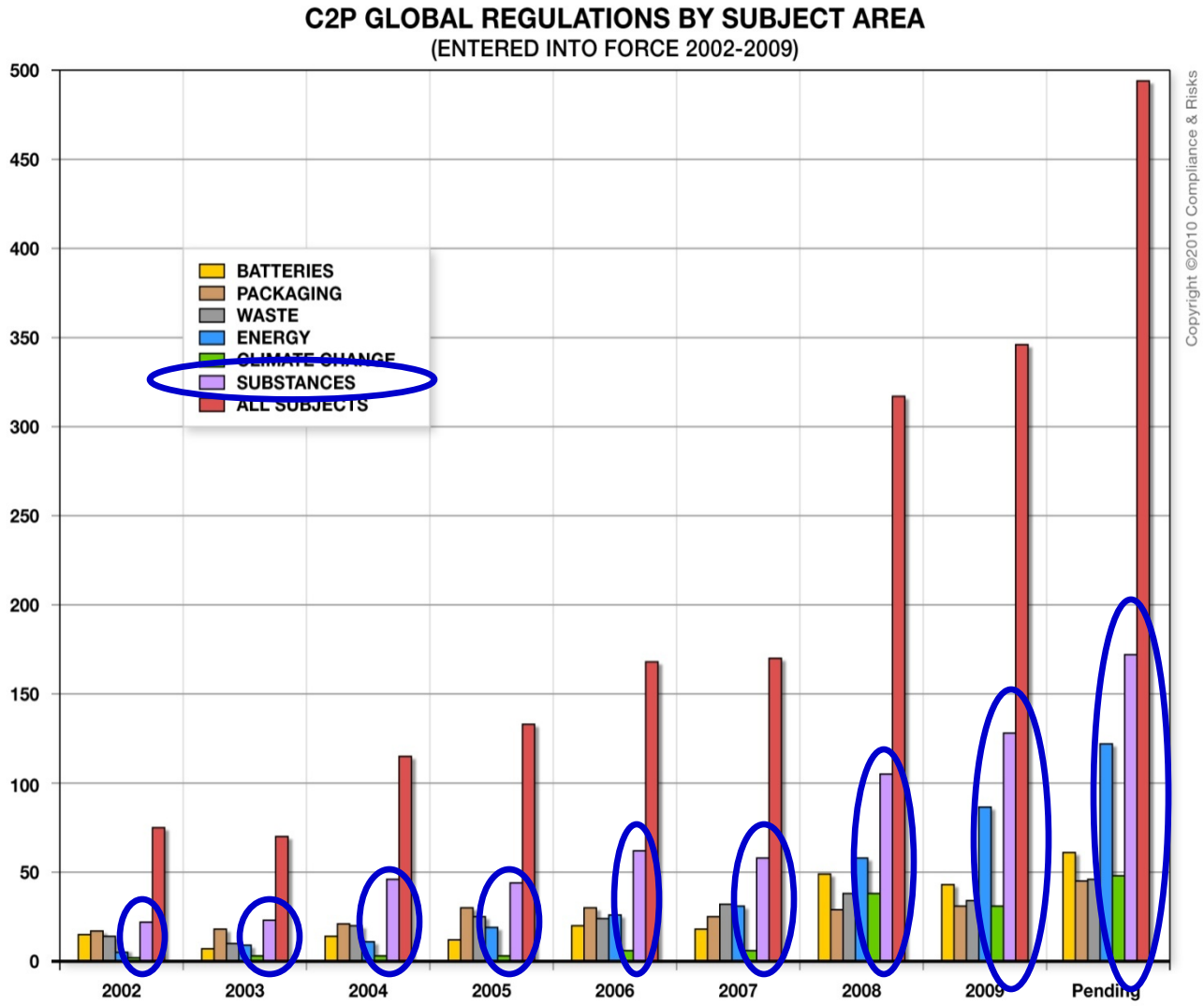
- TUR Options Evaluation process does not focus on finding safest alternative when looking at substitution options.
- So why should you care?

Your Customers May be Asking …

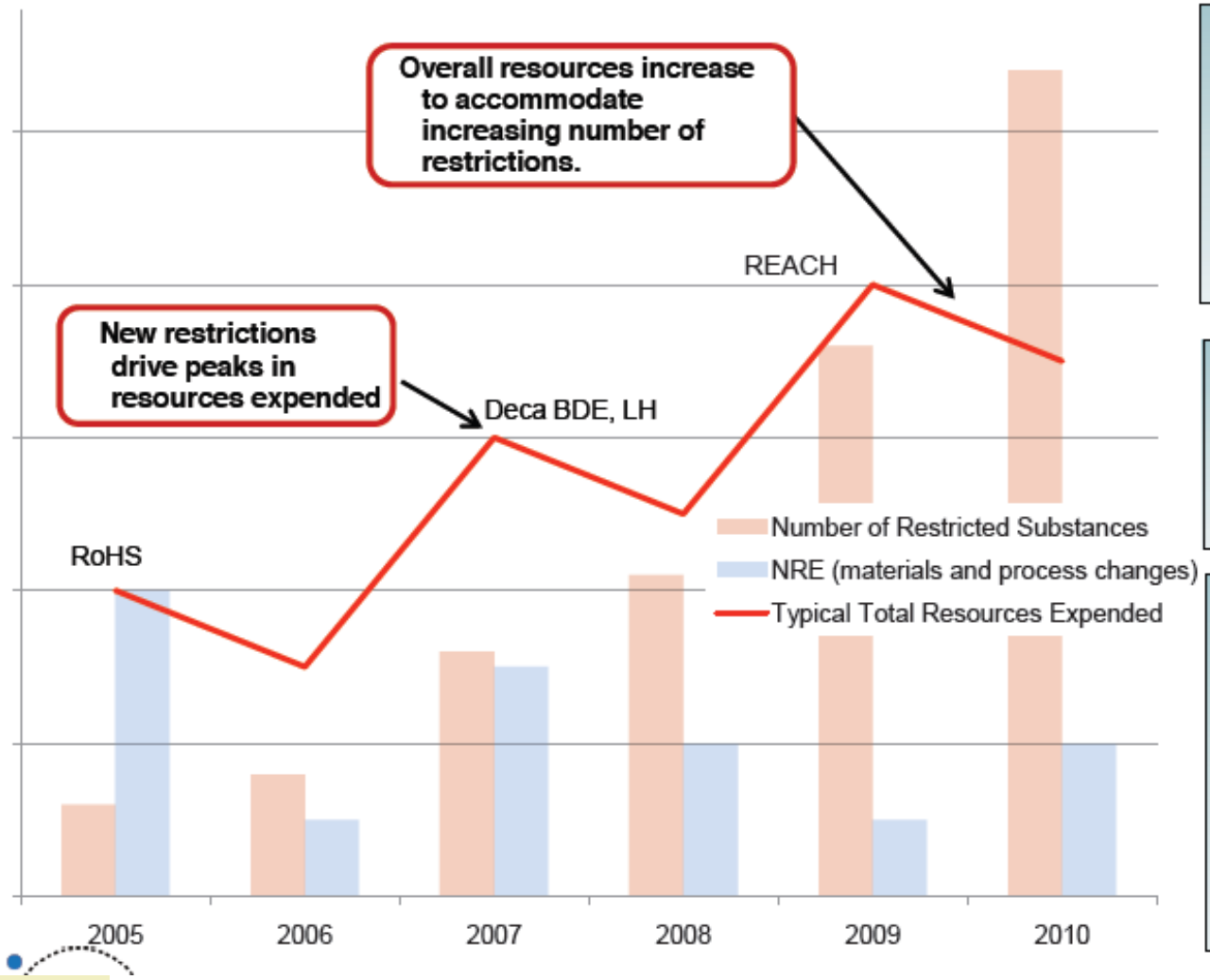
- Do you know all chemical and material ingredients in this product?
- Would you be willing to provide a full ingredient list for this product to us (the customer) or a third party?
- Does the product contain chemicals of high concern? Prop. 65? RoHS? REACH?

Regulatory Requirements

- State, federal and global restrictions continue to change



Resources required to gather data to meet new substance restrictions typically follow a 'sawtooth' line, and increase over time



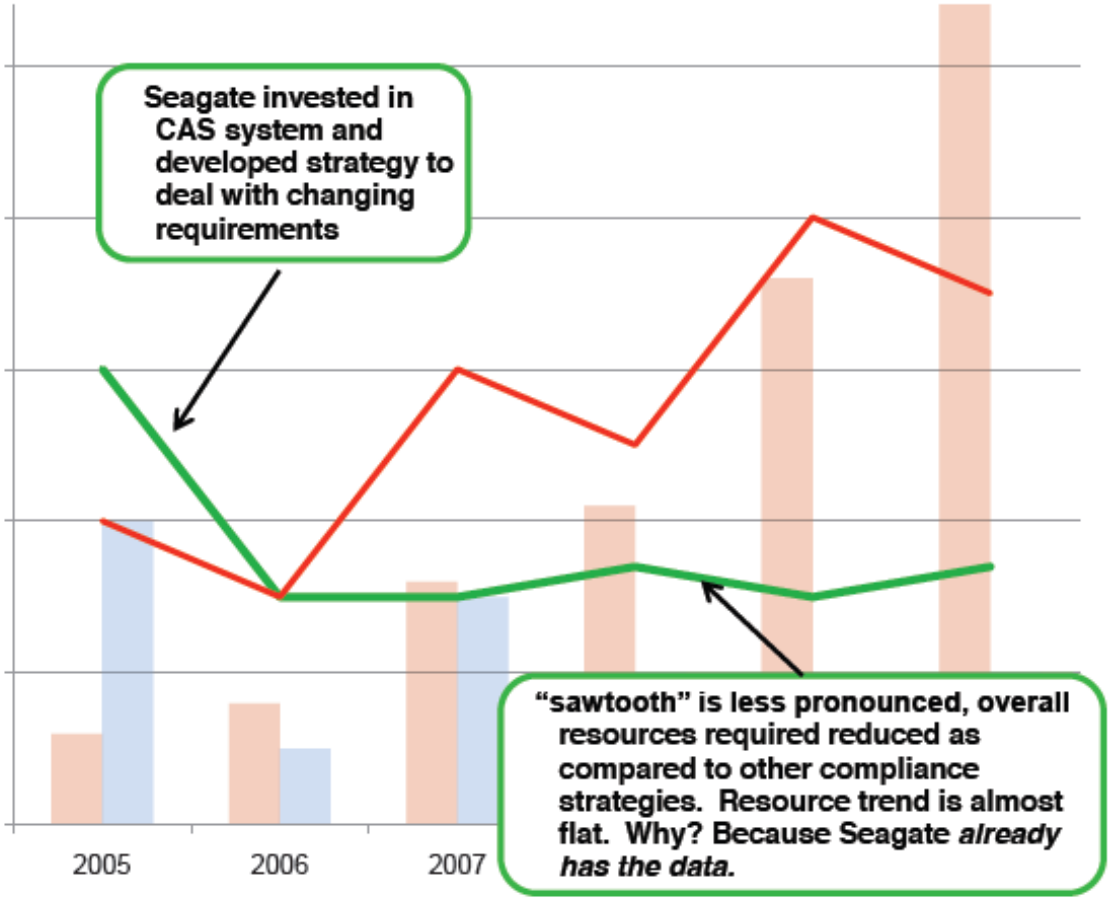
Emerging new restrictions result in spikes of NRE, business process change, and resource requirements

Non-regulatory restrictions, like low halogen, add even more requirements

Challenge: Produce environmentally friendly products that meet all regulatory and customer requirements while controlling overall cost of compliance.

This slide is courtesy of Brian Martin at Seagate

By investing 'early' in full data disclosure, Seagate has been able to flatten the 'sawtooth' in resource requirements for gathering substance data



Seagate is able to respond to new substance restrictions within current resources

Number of Restricted Substances
NRE (materials and process changes)
Resources Required - Strategic Approach
Typical Total Resources Expended

Seagate manages substance restrictions at low overall cost and with high credibility

This slide is courtesy of Brian Martin at Seagate

Small Group Discussion

- Are your customers asking for chemical ingredients or chemicals of concern?
- How do you generate chemical health and safety data?
- How do you identify and compare feasible substitutes?
- Do you monitor for availability of potential alternatives, and how?
- How do you choose?

Sources of Information

- Information portals:
  - Interstate Chemicals Clearinghouse
  - EU Substitution Portal

- Restricted Substances Lists
  - Industry lists
  - Government lists
  - NGO lists

Information Portals

- Web-based central location to find chemical data from government, NGO and other sources
- Emerging examples include:

- www.ic2saferalternatives.org

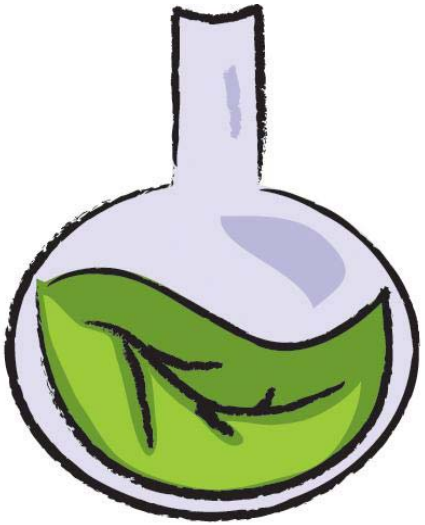
- http://www.subsport.eu/

Restricted Substances Lists

- Industry Lists:
  - Nike's "Considered Chemistry" Program
- Government Lists:
  - State lists: MA, WA, ME, CT
  - Swedish KemI restricted and phase out lists (Prio)
- NGO Lists
  - SIN list

Industry RSLs

- Companies are reluctant to publish their lists
- GC3 has assessed lists on confidential basis for 15 companies representing 4 different industry sectors



GC3 Green Chemistry & Commerce Council

Access their findings at:
http://www.greenchemistryandcommerce.org/publications.php

Swedish KemI - Prio

- Database to assist in avoiding exposures to toxic chemicals

PHASE-OUT SUBSTANCES	
Property	**Classification or other data to establish the property**
Carcinogenic (Category 1 and 2)	R45 May cause cancer R49 May cause cancer by inhalation
Mutagenic (Category 1 and 2)	R46 May cause heritable genetic damage
Toxic to reproduction (Category 1 and 2)	R60 May impair fertility R61 May cause harm to the unborn child
Endocrine disrupter	(See The criteria in detail)
Particularly hazardous metals (Cd, Hg, Pb)	(See The criteria in detail)
PBT /vPvB – Persistent, Bioaccumulating, Toxic / very Persistent, very Bioaccumulating	(See The criteria in detail)
Ozone-depleting substances	R59 Dangerous for the ozone layer

Prio

PRIORITY RISK-REDUCTION SUBSTANCES	
Property	**Classification or other data to establish the property**
Very high acute toxicity	R26 Very toxic by inhalation R27 Very toxic by skin contact R28 Very toxic by swallowing R39/26 Very toxic: danger of very serious irreversible effects through inhalation R39/27 Very toxic: danger of very serious irreversible effects in contact with skin R39/28 Very toxic: danger of very serious irreversible effects if swallowed
Allergenic	R42 May cause sensitisation by inhalation R43 May cause sensitisation by skin contact
High chronic toxicity	R48/23 Toxic: danger of serious damage to health by prolonged exposure through inhalation R48/24 Toxic: danger of serious damage to health by prolonged exposure in contact with skin R48/25 Toxic: danger of serious damage to health by prolonged exposure if swallowed
Mutagenic	R68 Possible risk of irreversible effects
Environmentally hazardous, long-term effects	R 50/53 Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment R53 May cause long-term effects in the aquatic environment
Potential PBT / vPvB	(See The criteria in detail)

http://www.kemi.se/templates/PRIOEngpage____4159.asp

Substitute It Now!

- An NGO driven project to speed up the transition to a toxic free world (Swedish goal)
- 356 chemicals that are Substances of Very High Concern based on the criteria established by the EU chemical regulation, REACH.

http://www.chemsec.org/list/about-sin

Tools for Finding Safer Substitutes

- Tools designed to identify and screen out hazardous chemicals *("bads")*
- Tools that facilitate comparisons between chemicals
- Tools that identify safer chemicals *("goods")*

Tools that ID the “Bads”

- These are tools that help to characterize and determine whether or not chemicals exhibit inherent characteristics that are strongly discouraged and/or banned from use

Dutch Quick Scan

- Considers exposure based on use type

Substances in concern category on basis of hazard and use[22)]

CONCERN ON BASIS OF HAZARD \ EXPOSURE ON BASIS OF USE	Use of substances as indication of exposure			
	Site limited intermediate substances	Substances in industrial applications	Open professional use of substances	Substances in consumer applications
	Low Exposure	Exposure	High exposure	Very high exposure
Very high concern	High concern	High concern	Very high concern	Very high concern
High concern	Concern	Concern	High concern	High concern
Concern	Concern	Concern	Concern	High concern
Low concern	Low concern	Low concern	Low concern	Concern
No data, very high concern	Very high concern	Very high concern	Very high concern	Very high concern

http://international.vrom.nl/pagina.html?id=37626

Predictive Screening Tools

- **PBT Profiler** (www.pbtprofiler.net) – models PBT characteristics of chemical based on structure of chemical
- **Oncologic™** (http://www.epa.gov/oppt/sf/pubs/oncologic.htm) – evaluates the likelihood that a chemical may cause cancer
- **ECOSAR** (http://www.epa.gov/oppt/newchems/tools/21ecosar.htm) – estimates the aquatic toxicity of industrial chemicals

Tools for Comparisons

- Hazard display tools
- Screening and decision guidance tools

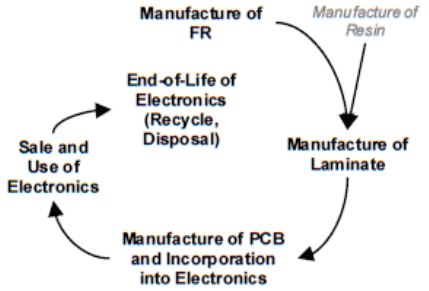
Design for the Environment

- Alternatives Assessments:
  - Flame Retardant alternatives in:
    - Furniture
    - Printed Circuit Boards
  - Bisphenol A alternatives in Thermal Paper
  - Lead-Free Solder alternatives in Electronics
  - Wire and Cable Heat Stabilizer alternatives
- Supports the EPA Chemical Action Plan process

http://www.epa.gov/dfe/alternative_assessments.html

Alternative flame retardants in PCBs

Chemical	CASRN	Human Health Effects									Aquatic Toxicity		Environmental		Exposure Considerations
		Acute Toxicity	Skin Sensitizer	Cancer Hazard	Immunotoxicity	Reproductive	Developmental	Neurological	Systemic	Genotoxicity	Acute	Chronic	Persistence	Bioaccumulation	Availability of FRs throughout the lifecycle for reactive and additive FR chemicals and resins
Additive Flame Retardants[3]															
Aluminum hydroxide															
Aluminum hydroxide	21645-51-2	L	L	L	M	L	L	M	L	L	H	M	H^R	L	
Exolit OP 930 (phosphoric acid, diethyl-, aluminum salt) (Clariant)															
Exolit OP 930	225789-38-8	L	L	L	M	L	M	M	L	L	M	M	H^R	L	
Melapur 200 (Melamine polyphosphate) (Ciba)[4]															
Melapur 200	218768-84-4	L	L	L	L	L	L	L	M	M	L	L	M	L	
Polyphosphoric acid	8017-16-1	L	L	L	L	L	L	L	L	L	L	L	L	L	
Melamine	108-78-1	L	L	L	L	L	L	L	M	M	L	L	M	L	
Silicon dioxide amorphous[5]															
Silicon dioxide amorphous	7631-86-9	L	L	L	L	L	L	L	H§	L	L	L	H^R	L	
Silicon dioxide crystalline[5]															
Silicon dioxide crystalline	1317-95-9	L	L	H‡	H§	L	L	L	H§	H§	L	L	H^R	L	
Magnesium hydroxide															
Magnesium hydroxide	1309-42-8	L	L	L	L	L	L	L	L	L	L	L	H^R	L	



[1] The moderate designation captures a broad range of concerns for hazard, further described in Table 4-3.
[3] Although additive flame retardants are present throughout the lifecycle of the PCB, they are locked into the polymer matrix of the epoxy laminate material.
[4] Melapur 200 dissociates in water to form polyphosphoric acid and melamine ions. For this reason, Table 4-1 includes both dissociation ions.
[5] Representative CAS numbers are included in this summary table. Section 4.2.9 includes a full list of CAS numbers.

http://www.epa.gov/dfe/pubs/projects/pcb/full_report_pcb_flame_retardants_report_draft_11_10_08_to_e.pdf

Pharos: Building Materials Selection Tool

Target Materials:

- PVC
- Pressure Treated Wood
- Plastic Lumber
- Formaldehyde
- Biopolymers

http://www.healthybuilding.net/news/061109pharos.html

P2OASys

Pollution Prevention Options Assessment System

The tool is designed to assist companies in two ways:

- Examine the potential environmental and worker impacts of options - the total impacts of process changes
- Compare options with the current process based on quantitative and qualitative factors.

Category	Units	Cert.	Score	Component		1
				TRICHLOROETHYLENE		
				%	100	
Acute human effects		**Cert**	**Score**	**Val**	**Sco**	**Cert**
Inhalation LC50	ppm					
PEL/TLV	ppm	100	4	100	4	100
PEL/TLV (dusts/particles)	mg/m3					
IDLH	ppm	100	2	1000	2	100
Respiratory irritation	L/M/H	100	8	m/h	8	100
Oral LD50	mg/kg	100	10	4	10	100
dermal irritation	L/M/H	100	4	l/m	4	100
skin absorption	L/M/H	100	2	l	2	100
dermal LD50	mg/kg					
ocular irritation	L/M/H	100	10	h	10	100
Chronic human effects		**Cert**	**Score**	**Val**	**Sco**	**Cert**
Reference Dose RfD	mg/kg/day					
carcinogen	IARC/EPA Class	100	8	b	8	100
mutagen	L/M/H	100	2	l	2	100
reproductive effects	L/M/H	100	2	l	2	100
neurotoxicity	L/M/H	100	6	m	6	100
developmental effects	L/M/H	100	2	l	2	100
respir. sensistivity/disease	L/M/H					
other chronic organ effects	L/M/H	100	6	m	6	100
Physical hazards		**Cert**	**Score**	**Val**	**Sco**	**Cert**
heat	WBGT, °C					
noise generation	dBA					
vibration	m/S^2					
ergonomic hazard	L/M/H					
psychosocial hazard	L/M/H					
Aquatic hazards		**Cert**	**Score**	**Val**	**Sco**	**Cert**
Water Quality Criteria (HWQC	mg/l					
aquatic LC50	mg/l	100	4	660	4	100
fish NOAEC	mg/l					
plant EC 50	mg/l	100	2	535	2	100
observed ecological effects	L/M/H	100	10	h	10	100
Persistence/bioaccumulation		**Cert**	**Score**	**Val**	**Sco**	**Cert**
persistence	L/M/H					
BOD half-life	days	100	6	20	6	100
hydrolysis half-life	days	100	8	330	8	100
bioconcentration	log kow	100	10	253	10	100
bioconcentration factor (BCF)	kg/l					
Atmospheric hazard		**Cert**	**Score**	**Val**	**Sco**	**Cert**
greenhouse gas	Y/N					
ozone depletor	ODP units					
acid rain formation	Y/N					
NESHAP	Y/N					
Disposal hazard		**Cert**	**Score**	**Val**	**Sco**	**Cert**
landfill	L/M/H					
EPCRA reportable quantity	lbs	100	6	100	6	100
incineration	L/M/H					
recycling	L/M/H					
Chemical hazard		**Cert**	**Score**	**Val**	**Sco**	**Cert**
vapor pressure	mm Hg	100	8	57.8	8	100
solubility in water	mg/L					
specific gravity	N/A					
flammability	0,1,2,3,4	100	4	1	4	100
flash point	°C	100	6	32	6	100
reactivity	0,1,2,3,4	100	2	0	2	100
pH	pH units					
corrosivity	L/M/H	100	2	l	2	100
High pressure system	L/M/H					
High temperature system	L/M/H					
mixture/reaction potential	L/M/H	100	6	m	6	100
odor threshold	L/M/H	100	10	h	10	100
volatile organic compound	L/M/H					
Energy & resource use		**Cert**	**Score**	**Val**	**Sco**	**Cert**
non renewable resource	L/M/H					
water use	L/M/H					
energy use	L/M/H					
Product hazard		**Cert**	**Score**	**Val**	**Sco**	**Cert**
upstream effects	L/M/H					
consumer hazard	L/M/H	100	2	l	2	100
disposal hazard	L/M/H	100	8	m/h	8	100
Exposure potential		**Cert**	**Score**	**Val**	**Sco**	**Cert**
Exposure potential	L/M/H	100	8	m/h	8	100

http://www.turi.org/home/hot_topics/cleaner_production/p2oasys_tool_to_compare_materials

Column Model

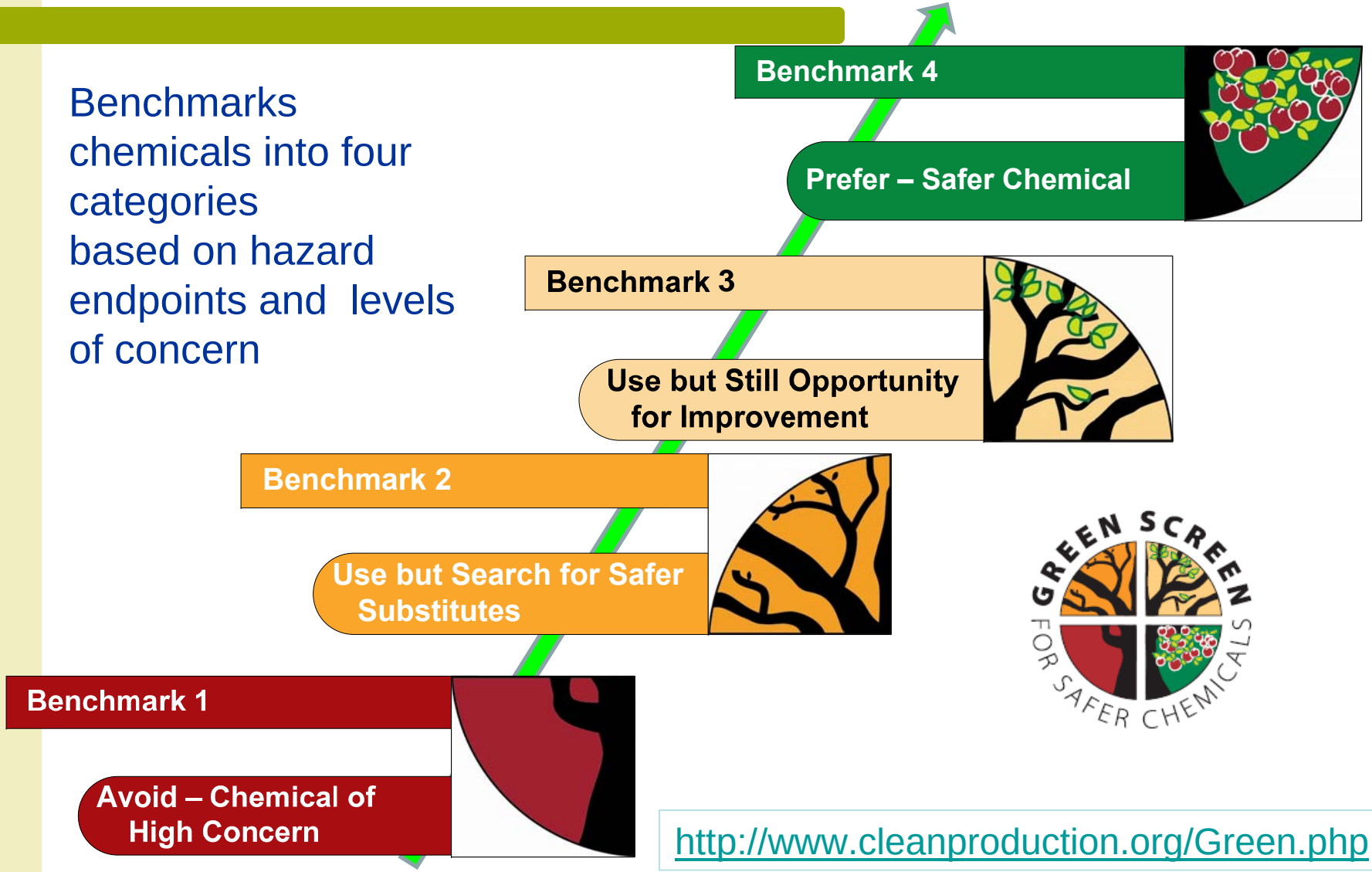
- Developed by the German Inst. for Occ. Safety
- Requires minimal info – obtained from MSDS/SDS

	Acute Hazards	Chronic Hazards	Environ-mental	Fire and Explosion	Exposure potential	Hazards caused by procedure
Very high	R26, R27, R28, R32	CMR (cat 1 or 2), R45, R49, R46	N, R50 – R59, WGK3	R2, R3, R12, R17	Gases, Liquid w/VP>250 hPA, dusts, aerosols	Open processing, direct skin contact, large area application
High	R23, R24, R25, R35, R29, R31, R43, Sh, R42, Sa	CMR (cat 3), R60, R61, R40, R68)		R41-R11, R14-R16, R19, R30, R44	50≤VP≤250 hPA	
Medium	R20, R21, R22, R64, R34, pH≥11.5, R41	Repr Cat. 3, R_E3, R_F3, R62, R63	N, R52, R53, WGK2	R10	10 ≤ VP ≤ 50 hPA	Closed processing but exposure possible (e.g., filling, sampling, cleaning)
Low	R36, R37, R38, R65, R66, R67	Otherwise affecting	WGK1	55°C ≤ FP ≤ 100°C	2 ≤ VP ≤ 10 hPA	
Negligible	Harmless substance by experience		Not water polluting	FP>100°C	VP<2 hPA, solids releasing no dusts	Tightly closed equip, closed equip w/ exhaust

http://www.dguv.de/ifa/en/pra/spalte/index.jsp

Green Screen for Safer Chemicals

Benchmarks chemicals into four categories based on hazard endpoints and levels of concern



GREEN SCREEN FOR SAFER CHEMICALS

http://www.cleanproduction.org/Green.php

Tools that ID the “Goods”

- These are tools that help you quickly select preferred products or chemicals, based on established criteria

Databases

- TURI Safer Solutions Database: http://www.turi.org/turi_lab/cleanersolutions_database

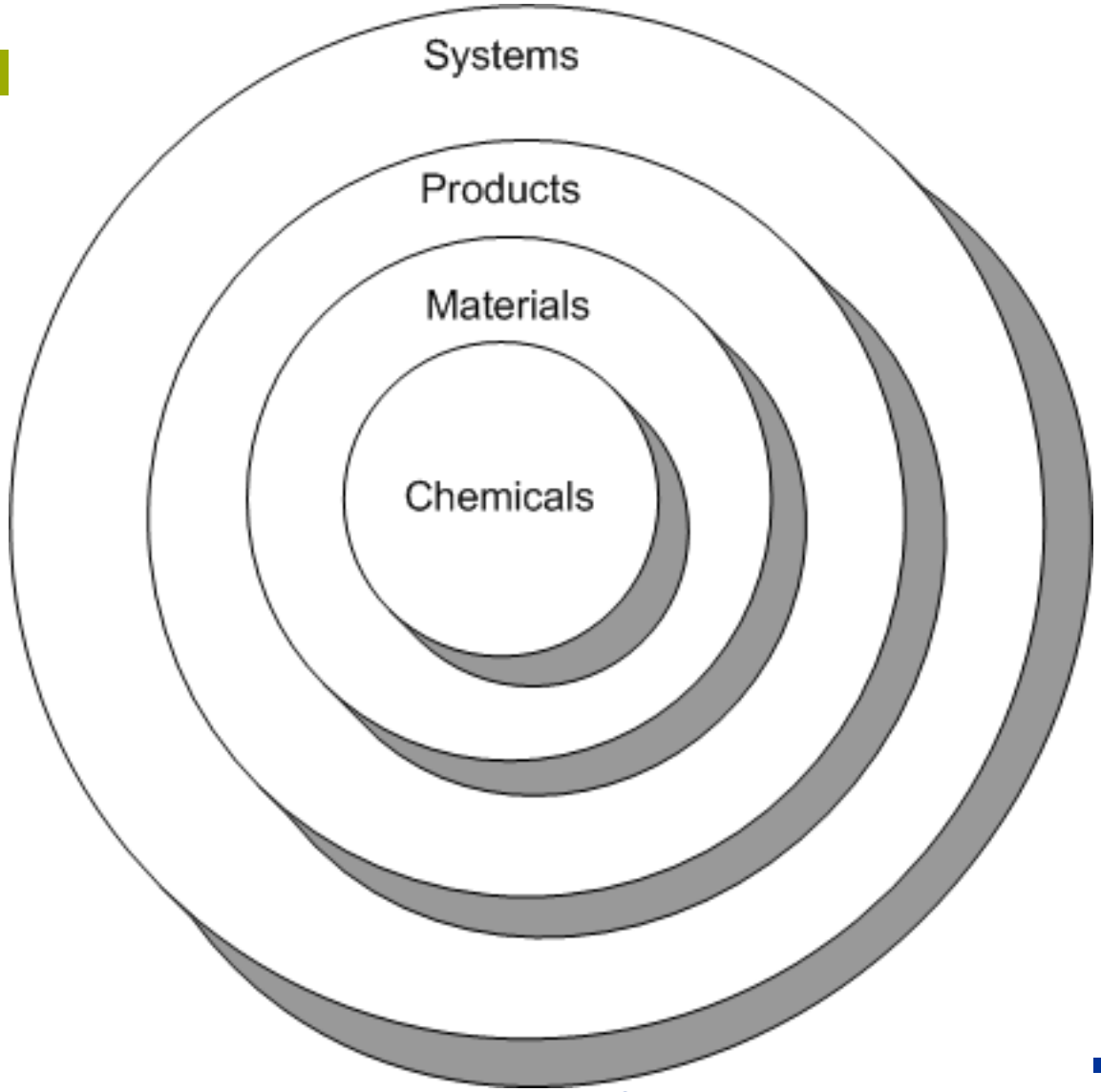
- cleangredients®: http://www.cleangredients.org/home

Works in tandem with DfE label

Ecolabels and Certifications

- EPA DfE label: http://www.epa.gov/dfe/pubs/projects/formulat/formpart.htm
- Green Seal: http://www.greenseal.org/findaproduct/index.cfm
- Cradle to Cradle Products Innovation Institute: http://www.c2ccertified.org/

Chemicals are Part of a System

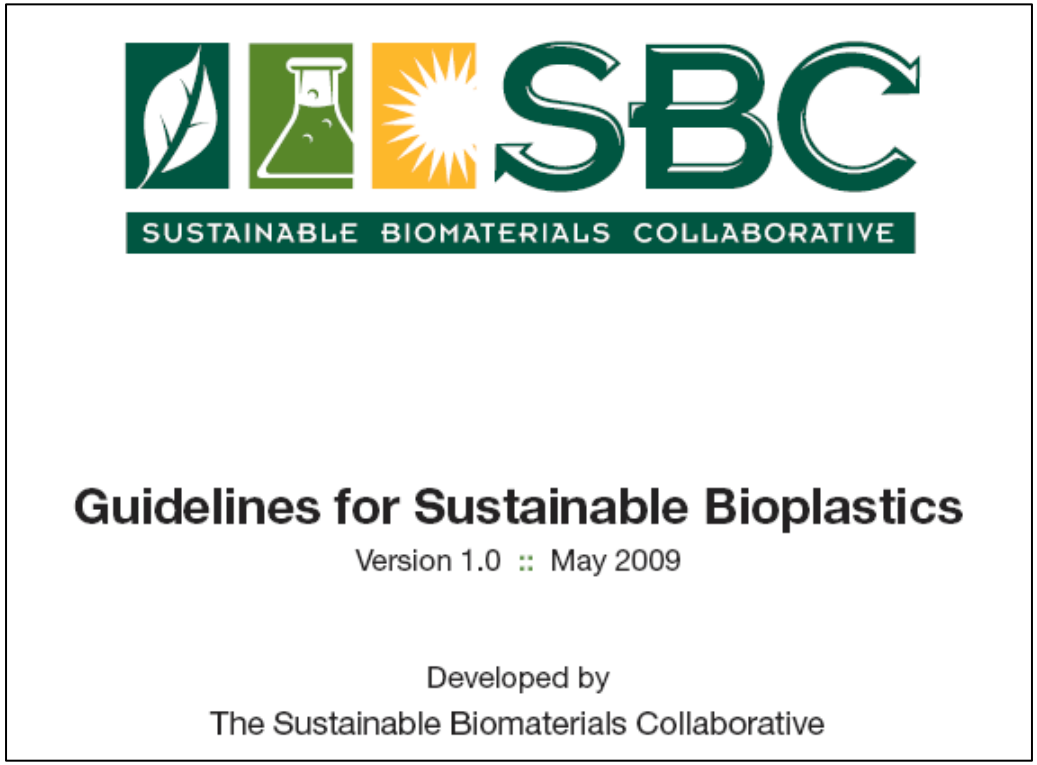


How Do You Compare Different Materials?

- Examples of changes in materials you've considered
- What criteria do you consider?
- What tools do you use?
  - Life Cycle Assessment

Defining Sustainable Life Cycles by Principles

- Sustainable feedstocks / Sustainable agriculture
- Green Chemistry & Clean Production
- Closed Loop Systems / Cradle to Cradle / Zero Waste




Sustainable Feedstocks?

What Should the Sustainability Criteria be for Feedstocks?

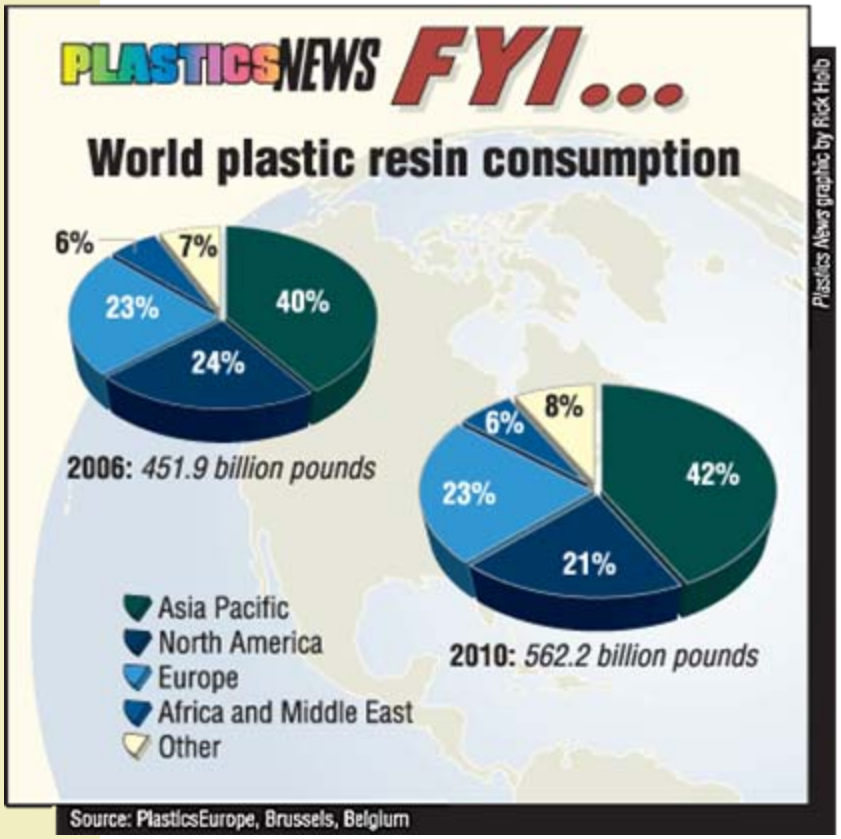
- Are made from:
  - waste products (for example, ag waste)
  - low environmental impact resources (such as algae)
  - sustainably grown crops / trees
- Do not use genetically modified organisms (GMOs) in the field
- Do not use or result in the generation of chemicals of high concern
- Use renewable energy
- Protect / enhance air & water quality
- Promote biological diversity
- Minimize water use and transportation
- Local / regional sourcing
- Safe & healthy working conditions

Sustainable Production?

What Should the Sustainability Criteria be for Manufacturing?

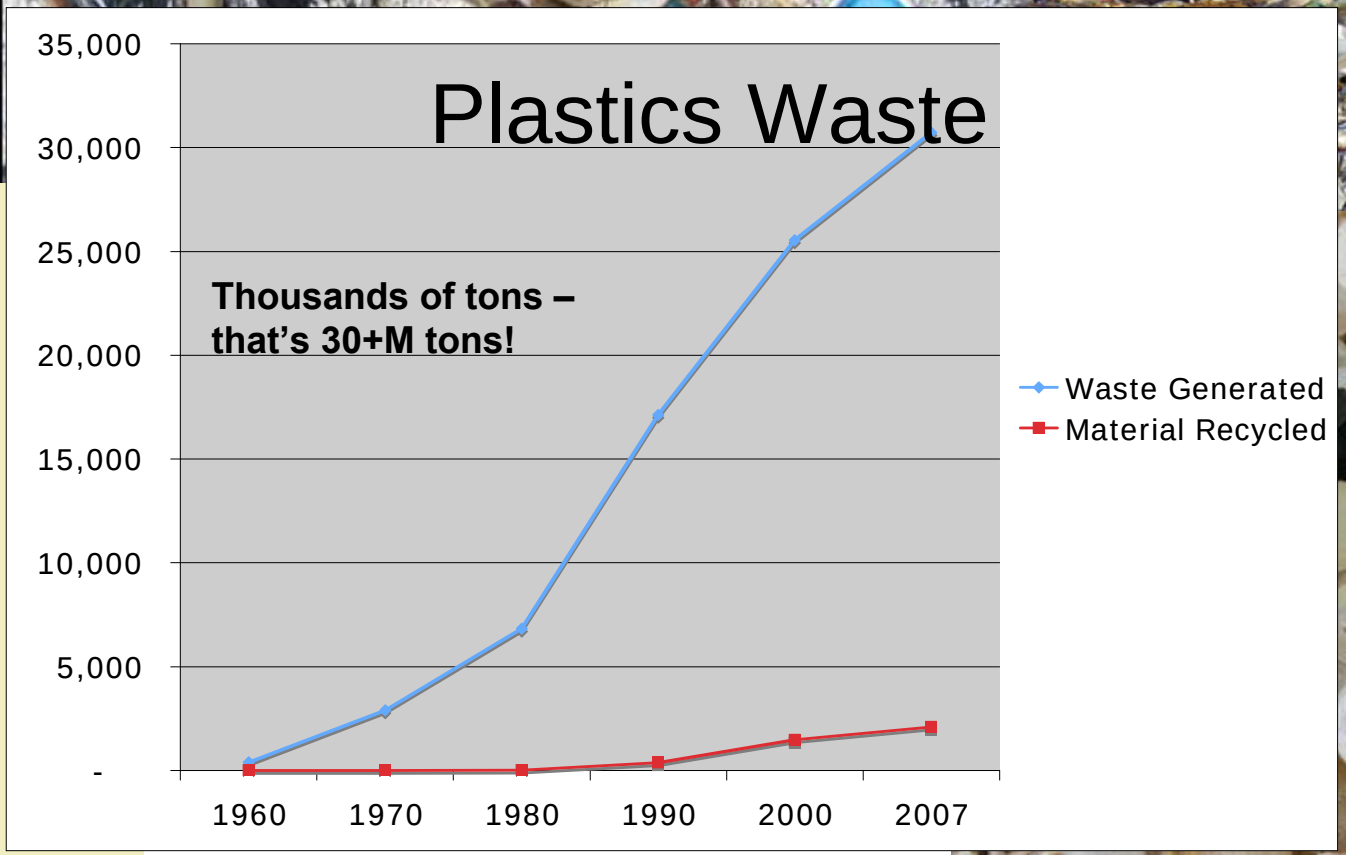
- Optimize recycled content / buy sustainable feedstocks
- Use inherently less hazardous chemicals
- Exercise caution with nanomaterials
- Product designed for reuse, disassembly, recycling or composting
- Use renewable energy
- Minimize energy use, water use, pollution and waste
- Label material content
- Local / regional sourcing
- Safe & healthy working conditions

Toxics in Plastics



- Additives
- Primary chemicals – for example, benzene
- Monomers – vinyl chloride monomer (PVC), styrene (PS), bisphenol A (PC)

Cradle to Cradle?



What Should the Sustainability Criteria be for End of Life?

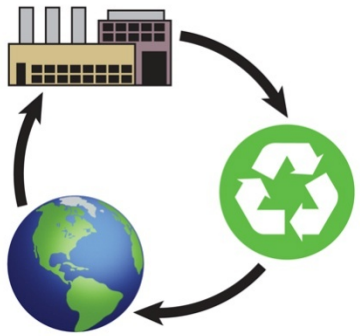
- **Product is reused, repaired, recycled or composted**
- For compostable - safe and rapid biodegradation (soil and marine environments)
- Clear labeling
- Create infrastructure for takeback, recycling, composting
- Safe & healthy working conditions

Tools for Identifying more Sustainable Plastics

- **BioSpecs** - Environmentally Preferable Purchasing Specifications for Compostable Biobased Food Service Ware (*v.1.0 beta)*

- **Plastics Scorecard** (*v.1.0 beta)*

BioSpecs & Plastic Scorecard



BioSpecs

- Biobased - renewable raw materials, including:
  - Plastics (e.g., PLA, starch-based biopolymers)
  - Fibers (e.g., bagasse, cellulose)
- Product – initially, compostable food service ware
- Life cycle: biomass, mfg, EOL
- Designed *like* an ecolabel

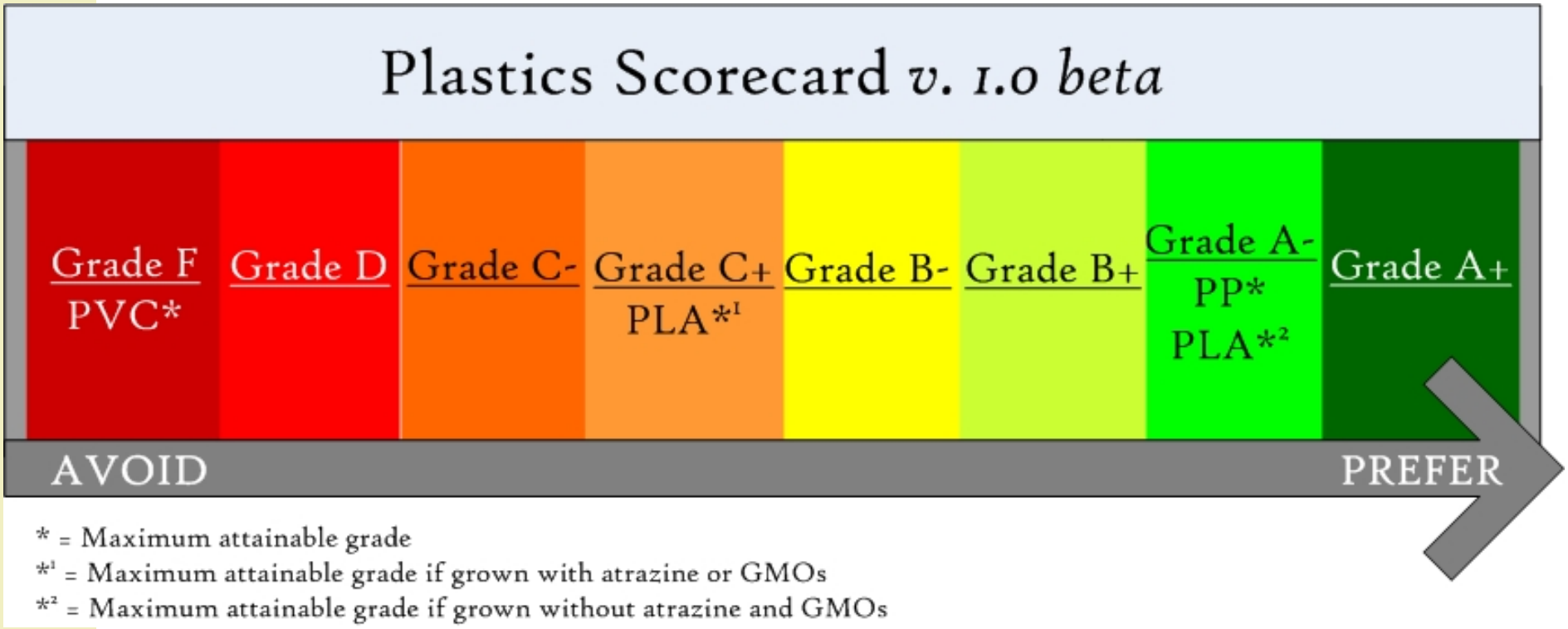
  Voluntary guidelines - criteria set 3 levels (bronze, silver, gold)

Plastics Scorecard

- Material (plastics) evaluation tool that integrates end of life issues
- Plastics – both bio- and fossil fuel-based
- Life cycle: raw mat'ls, mfg, use and end of life (EOL)
- Grades plastics on a scale of "F" to "A+"

BioSpecs – **DRAFT** Bronze Criteria

- Biomass Production
  - Product must contain >90% biobased organic carbon (by total carbon weight, not total product weight)
  - GM allowed in the field with offsets (Silver – no GM allowed)
- Manufacturing
  - Fibers: 100% PCR non-food contact; 10% PCR food content
  - No organohalogens (fluorine, bromine, chlorine) intentionally added
  - No engineered nanomaterials without testing
- End of Life
  - Must be commercially compostable
  - Clearly labeled “commercially compostable”
  - Clearly labeled when sold in areas where no commercial composting is available



The inherent characteristics of a plastic's chemistry set its baseline as well as maximum level of performance in the Scorecard.

Plastics Scorecard

Plastics Scorecard & BizNGO

- Revising the Scorecard
- Proposed Scope
  - In scope : inherent life cycle attributes of the material, especially cradle-to-gate
  - Out of scope: product-specific attributes
  - Rationale:
    - Leverage core competencies of Clean Production Action & BizNGO
    - General tool that can be used in conjunction with existing tools and metrics such as Outdoor Industry Association's Eco-Index

Parting Thoughts

- Life cycle thinking – taking a “principle-based” approach to sustainable materials
  - Define what we want
  - Set Priorities
    - Sustainable Feedstocks
    - Green Chemistry
    - Cradle to Cradle
- Transitioning from fossil fuels to renewable, bio-based feedstocks
  - Biobased not inherently better
  - Need criteria & standards for defining sustainable biomaterials and plastics across their life cycle

BioSpecs – www.SustainableBiomaterials.org

Plastics Scorecard – www.CleanProduction.org

Conclusion

- Substitute Chemicals and Materials are great TUR options
- Customers and regulations dictate that companies pay closer attention to substitutes chosen
- Tools and methods are available to help in that process
- Being systematic about this will help avoid future problems.