A MULTI-CRITERIA APPROACH TO ALTERNATIVES ASSESSMENT

Alternatives Assessment Symposium
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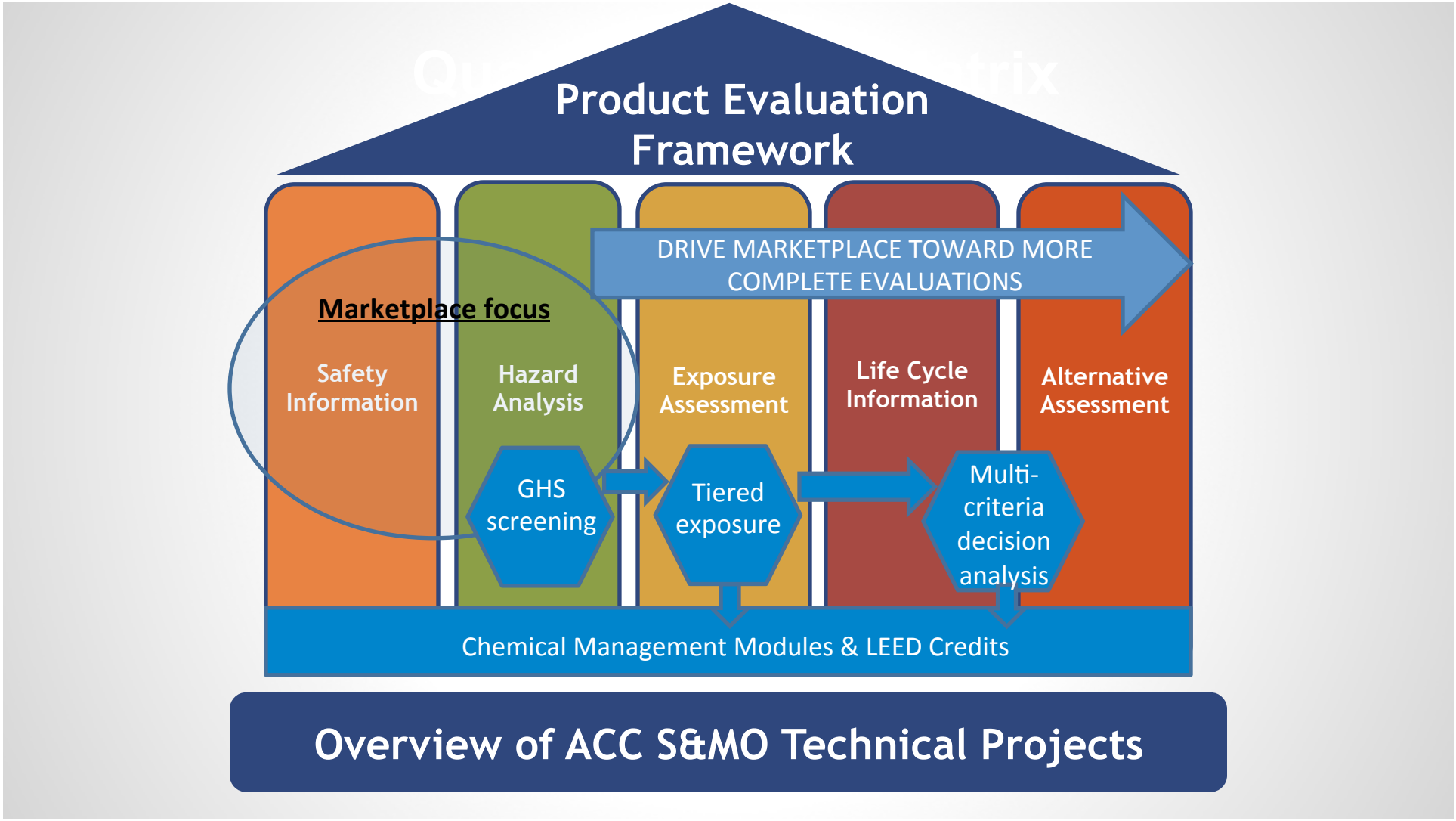
American® Chemistry Council



Overview of ACC S&MO Technical Projects

Single Attribute

One aspect drives decisions

Incomplete view of impacts

Hazard
Energy Use
Carbon Footprint

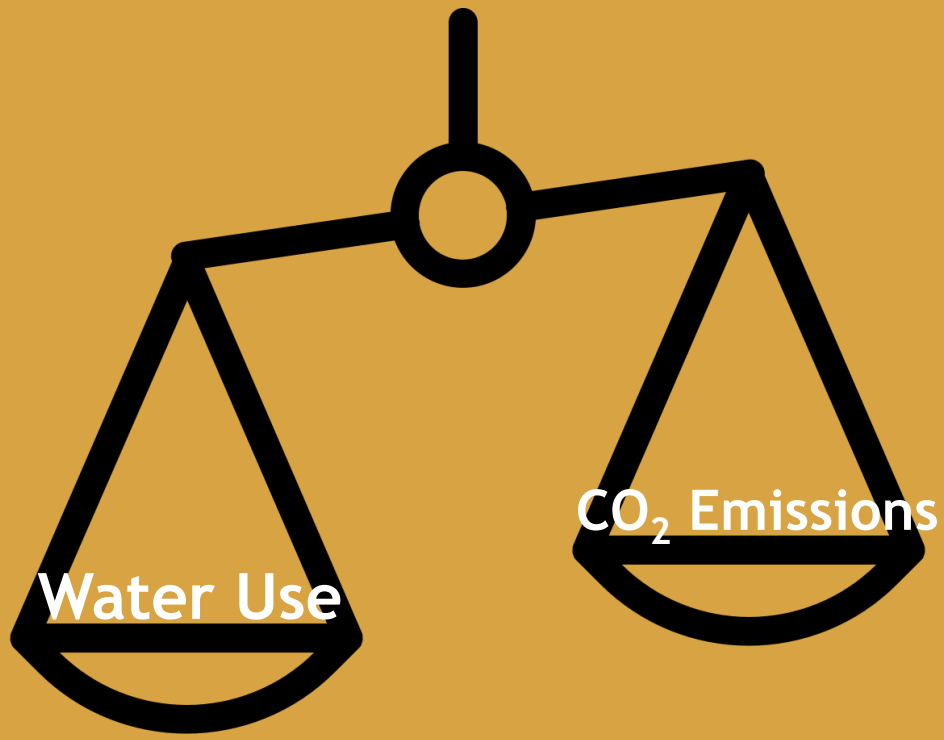
Multi Attribute

Holistic approach

Comprehensive view of impacts

Human Health
Environment
Performance
Economic
Other

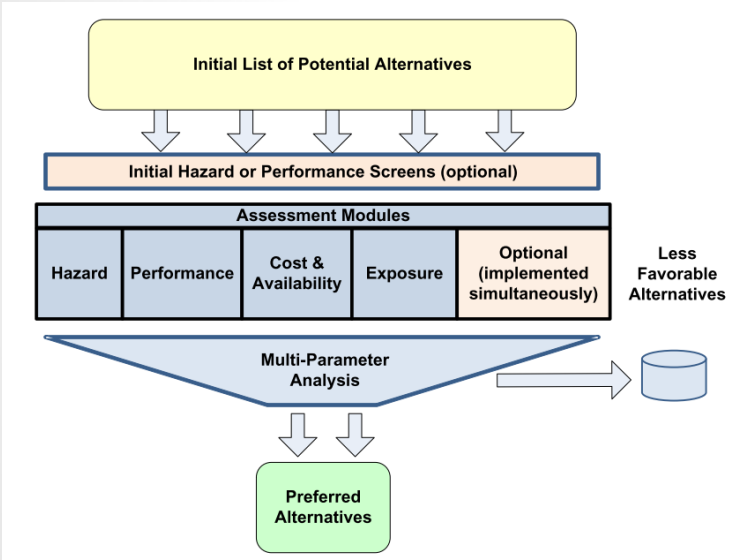
The Benefits of a Multi - Attribute Approach

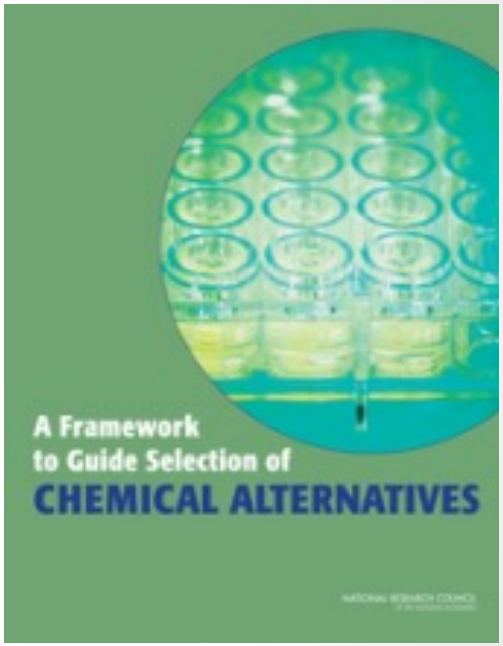


- Select and prioritize decision making criteria
- Understand tradeoffs
- Inform decisions based on user preferences
- Help prevent regrettable substitutions
- Interactive web-based interface

Alternatives Assessments

Multi-Criteria Considerations





IC2 Framework

http://theic2.org/alternatives_assessment_guide

National Academies

https://www.nap.edu/catalog/18872

MCDA Provides Benefits Along the Value Chain

Consumers		Gain knowledge about ingredient function and product safety.
Brands		Inform discussions with Customers. Prioritize chemical-related issues.
Professionals		Offer customers enhanced information related to chemical and product safety.
Retailers		Prioritize chemical-related issues. Support informed decision-making.

Multi-Criteria Decision Analysis

Data Input

Performance	
Alternative A	100%
Alternative B	90%
Alternative C	50%

Climate Change	
Alternative A	7.55 kg CO_2 eq / kg
Alternative B	3.57 kg CO_2 eq / kg
Alternative C	5.56 kg CO_2 eq / kg

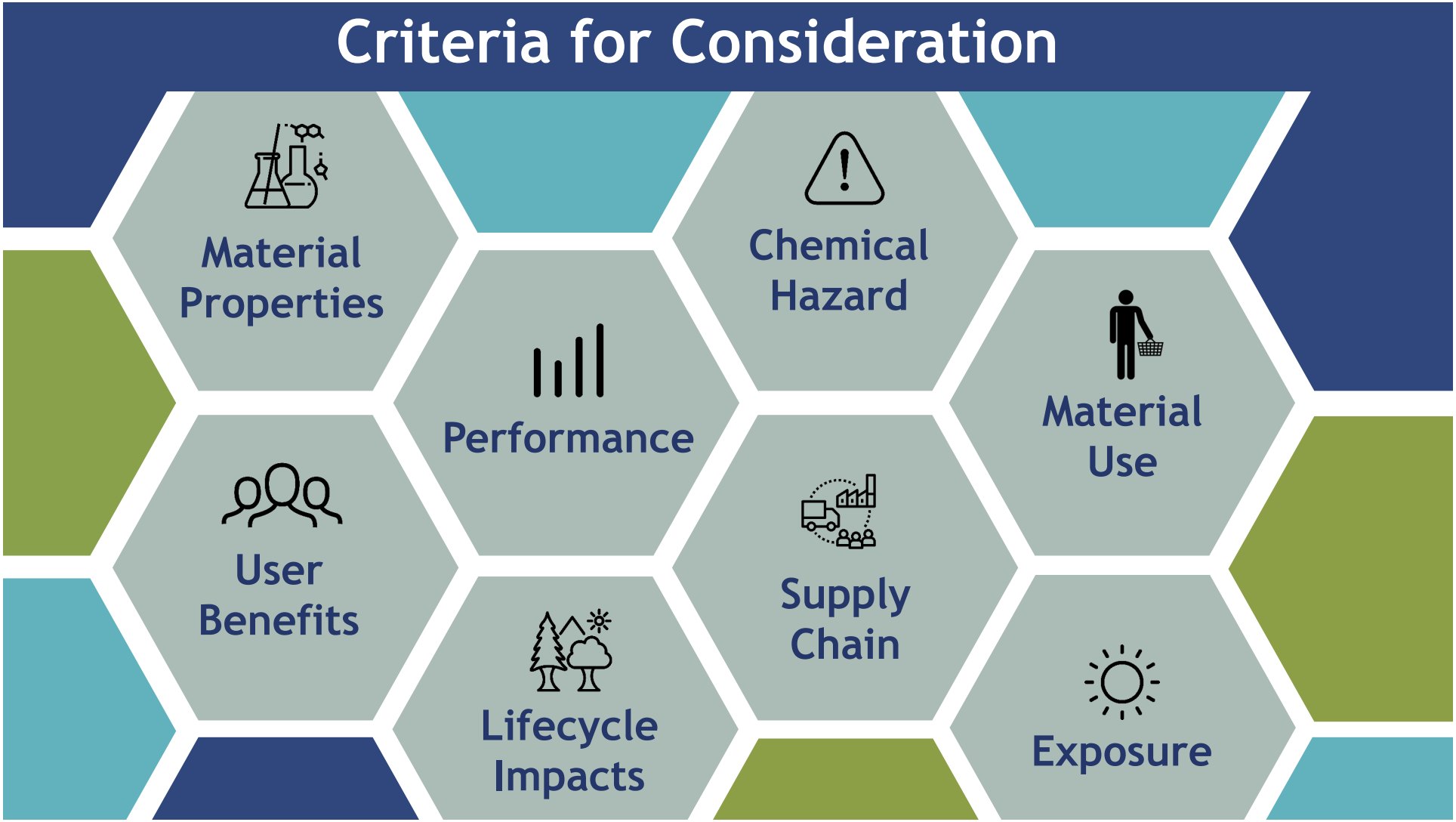
Ozone Depletion	
Alternative A	67 mg CFC-11 eq / kg
Alternative B	0
Alternative C	0

User Preferences

Tailored Results

Rankings by User Perspective			
Alternative	User 1	User 2	User 3
A	3	3	1
B	1	2	3
C	2	1	2

Criteria for Consideration



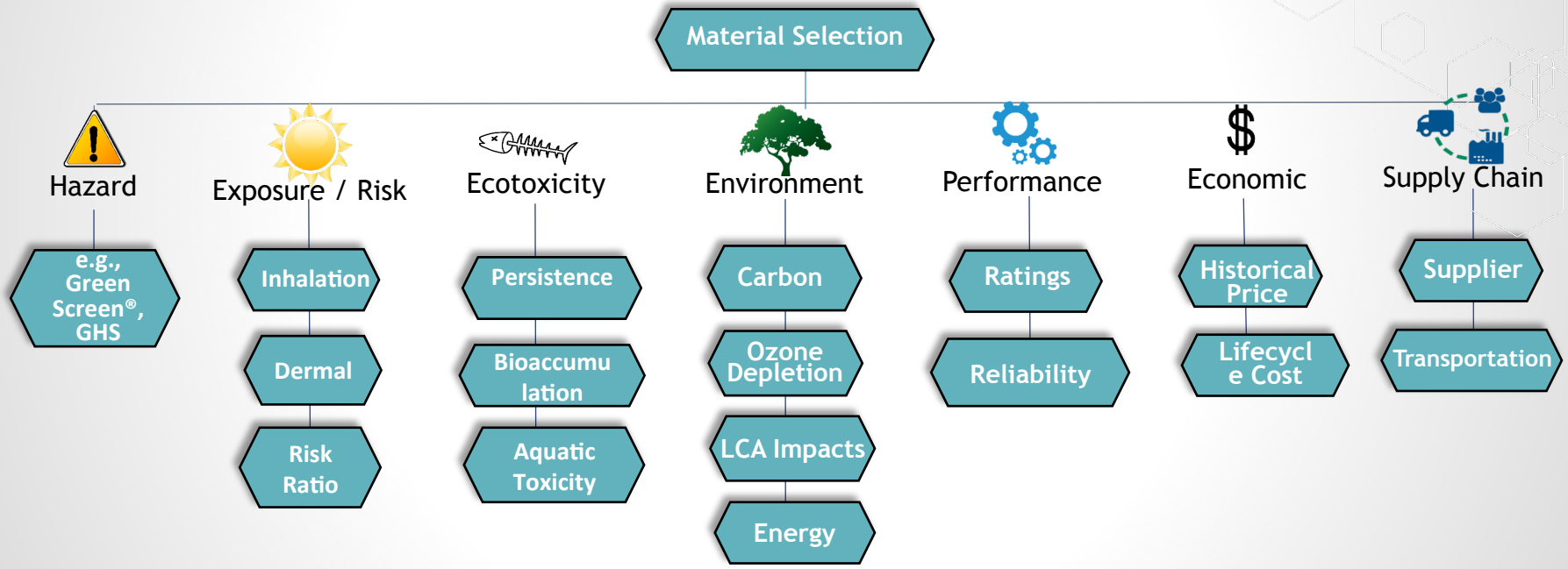
Master Criteria List

Master Criteria	CA DTSC AA Guide	NAS Framework	REACH (ECHA)	IC2 AA Guide	Umass Lowell AA Framework	U.S. EPA DfE Program	ProScale multi-criteria tool
Human Health Hazard	✔	✔	✔	✔	✔	✔	✔
Exposure Characteristics	✔	✔	✔	✔			✔
Eco-toxicity	✔	✔	✔	✔	✔	✔	✔
Physical / Chemical Hazards	✔	✔		✔	✔	✔	✔
Performance	✔	✔	✔	✔	✔	✔	✔
Lifecycle Impacts		✔		✔	✔	✔	✔
Supply Availability	✔			✔	✔		
Legal Considerations	✔						
Economic Feasibility	✔	✔	✔		✔		
Social Justice					✔		

*This list is only a summary, intended to illustrate high-level consensus around criteria. The presence or absence of a check mark should not be viewed as definitive for any given framework.

Alternatives Assessment Structure

Definition: A framework to compare multiple potential solutions in the context of a specific objective.



Demonstration - Marine Boat Paint Study

Multiple Attributes

- **Hazard**
- **Lifecycle Cost**
- **Performance**
- **Comparative Exposure**

Converting Selection Guide to Data Visualization

Product Information				Hazard										Cost			Performance				Exposure									
Product Identity			General	Human Hazard		Biocide				Environment		Regulatory		Initial/DIY		Cumulative	Assumes manufacturer longevity		Longevity		Gallons to cover 100 ft²			Grams Biocide to cover 100 ft²		Fate		Grams VOCs to cover 100 ft²	
Company	Product	Mechanism	Disclosure	Chronic human (CMRDE)	Neuro/Resp	Biocide	Amount	Persistence	Bioaccumulation	PBTaq combos	Puget Sound CoCs	Boatyard CoCs (Zn)	VOC content (g/L)	Per gallon	Per 100 ft²	35' boat over 5 years	Overall Recommendation	Customer Reviews # reviews, + or -)	Manufacturer longevity (years)	# of applications over 5 years	Initial (gallons)	5 year (gallons)	Biocide	Initial (grams)	5 years (grams)	Leach (Y/N)	Ablate (Y/N)	Initial (grams)	5 years (grams)
Coval	Marine and Hull Coat	Foul release, ceramic/ quartz	Full	0%	0%	none	0%	-	-	0%	0%	0%	< 100	$512.33	$166.51	$4034.94	Data Gap		5	1	0.3	0.3	N	0	0	N	N	< 123	< 123
CeRam-Kote	54 SST	Foul release, ceramic	SDS	26% - 53%	0%	none	0%	-	-	0%	0%	0%	< 197	$125.00	$125.00	$3886.75	Data Gap		5	1	1.0	1.0	N	0	0	N	N	< 746	< 746
ePaint	EP-2000	Photoactive and Biocidal, ZnPy	Full	5% - 10%	5% - 5%	ZnPy	4.8%	*H*	**vL**	35% - 45%	29% - 38%	29% - 37%	< 100	$210.91	$301.30	$6977.28	Likely to meet expectations	2 reviews +	3	2	1.4	2.9	Y	259.8	519.7	Y	Y	< 541	< 1083
Sherwin Williams	Sea Voyage	Biocidal, ZnPy and Econea	Full	9% - 9%	37% - 37%	ZnPy / Econea	6.4% / 7.35%	*H / H*	**vL / vL**	27% - 27%	32% - 32%	23% - 23%	< 340	$225.00	$289.29	$6891.49	Likely to meet expectations		3	2	1.3	2.6	Y	311.3 / 357.5	622.6 / 715.	Y	Y	< 1654	< 3308
Interlux	Micron CF	Biocidal, ZnPy and Econea	SDS Plus	1% - 16%	9% - 18%	ZnPy / Econea	4.12% / 3.9%	*H / H*	**vL / vL**	21% - 61%	19% - 47%	9% - 21%	330	$267.95	$103.46	$5564.67	Borderline		3	2	0.4	0.8	Y	60.8 / 57.6	121.6 / 115.2	Y	Y	487	974
ePaint	SN-1	Photoactive and Biocidal, Seanine	Full	11% - 34%	11% - 11%	Seanine	2.9%	**L**	*vL*	20% - 50%	17% - 41%	16% - 40%	< 400	$200.00	$222.22	$8921.48	Likely to meet expectations		2	3	1.1	3.3	Y	121.9	365.6	Y	Y	< 1681	< 5042
ePaint	ZO	Photoactive and Biocidal, ZnPy	Full	6% - 20%	16% - 16%	ZnPy	4.8%	*H*	**vL**	35% - 50%	32% - 51%	29% - 41%	< 400	$285.00	$275.81	$8912.89	Borderline	1 review +	2	3	1.0	2.9	Y	176.2	528.7	Y	Y	< 1469	< 4406
Pettit	Hydro-coat ECO	Biocidal, ZnPy and Econea	Full	<0.5%	11% - 11%	ZnPy / Econea	4.8% / 6%	*H / H*	**vL / vL**	9% - 14%	5% - 9%	5% - 9%	< 150	$268.99	$125.11	$7298.93	Likely to NOT meet expectations	2 reviews +	2	3	0.5	1.4	Y	85.4 / 106.7	256.2 / 320.2	Y	Y	< 267	< 801
Pettit	Ultima ECO	Biocidal, ZnPy and Econea	Full	14% - 27%	45% - 49%	ZnPy / Econea	4.8% / 6%	*H / H*	**vL / vL**	13% - 23%	16% - 37%	9% - 17%	320	$249.99	$149.99	$7565.39	Likely to NOT meet expectations	2 reviews +	2	3	0.6	1.8	Y	109. / 136.3	327.1 / 408.8	Y	Y	727	2180

Source: NW Green Chemistry Anti-Fouling Paint AA Final Report, Oct 2017

Pairwise Comparisons

Consumer Preferences

Perf:	11
Climate:	62
Risk:	45
Ozone:	87
Energy:	10
Water:	27
Cost:	5

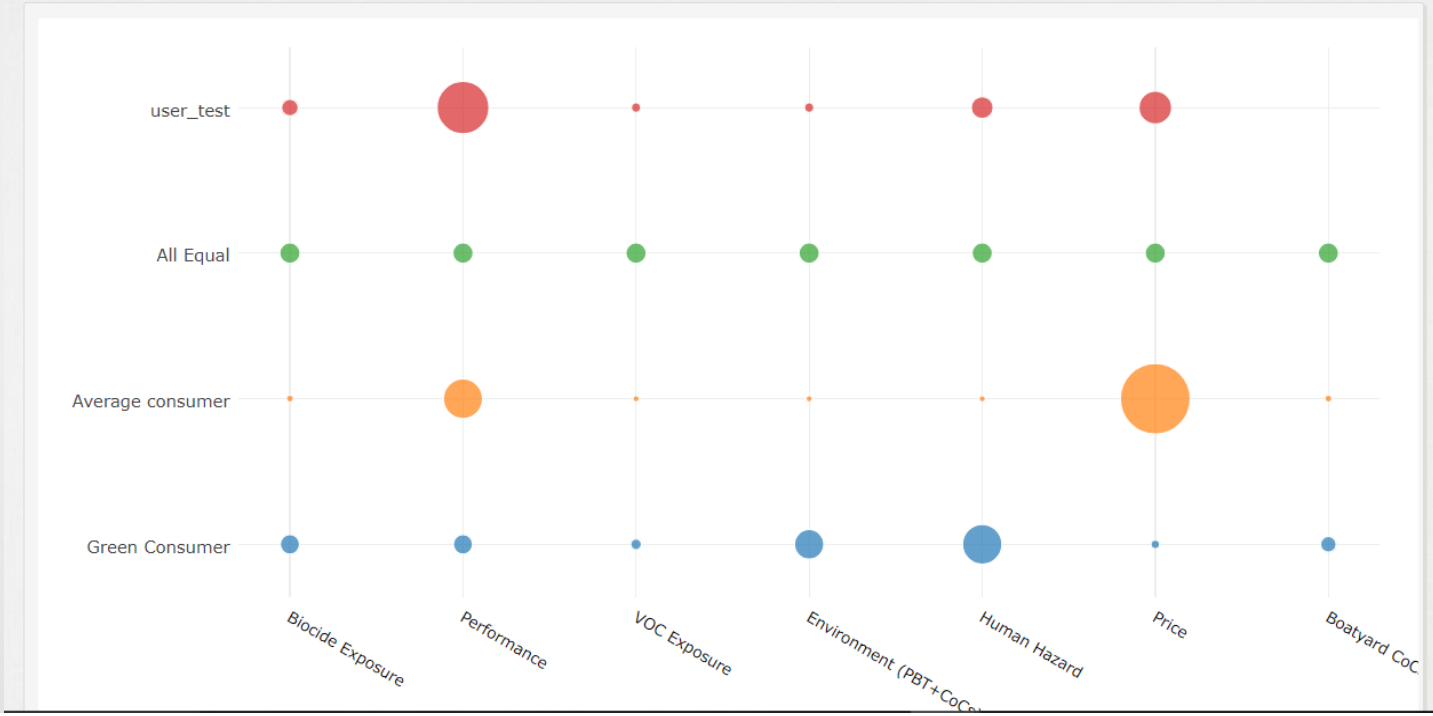
Professional Preferences

Perf:	89
Climate:	12
Risk:	36
Ozone:	23
Energy:	45
Water:	27
Cost:	75

Customizing Weighting Factors

Criteria Weights Edit weights

The weights determine how the different criteria (price, performance, etc.) are combined. A higher weight means more influence of the category. Weights depends on the person's perspective - that's why we show you some example perspectives to start with. To edit them or add your own, click on edit weights.

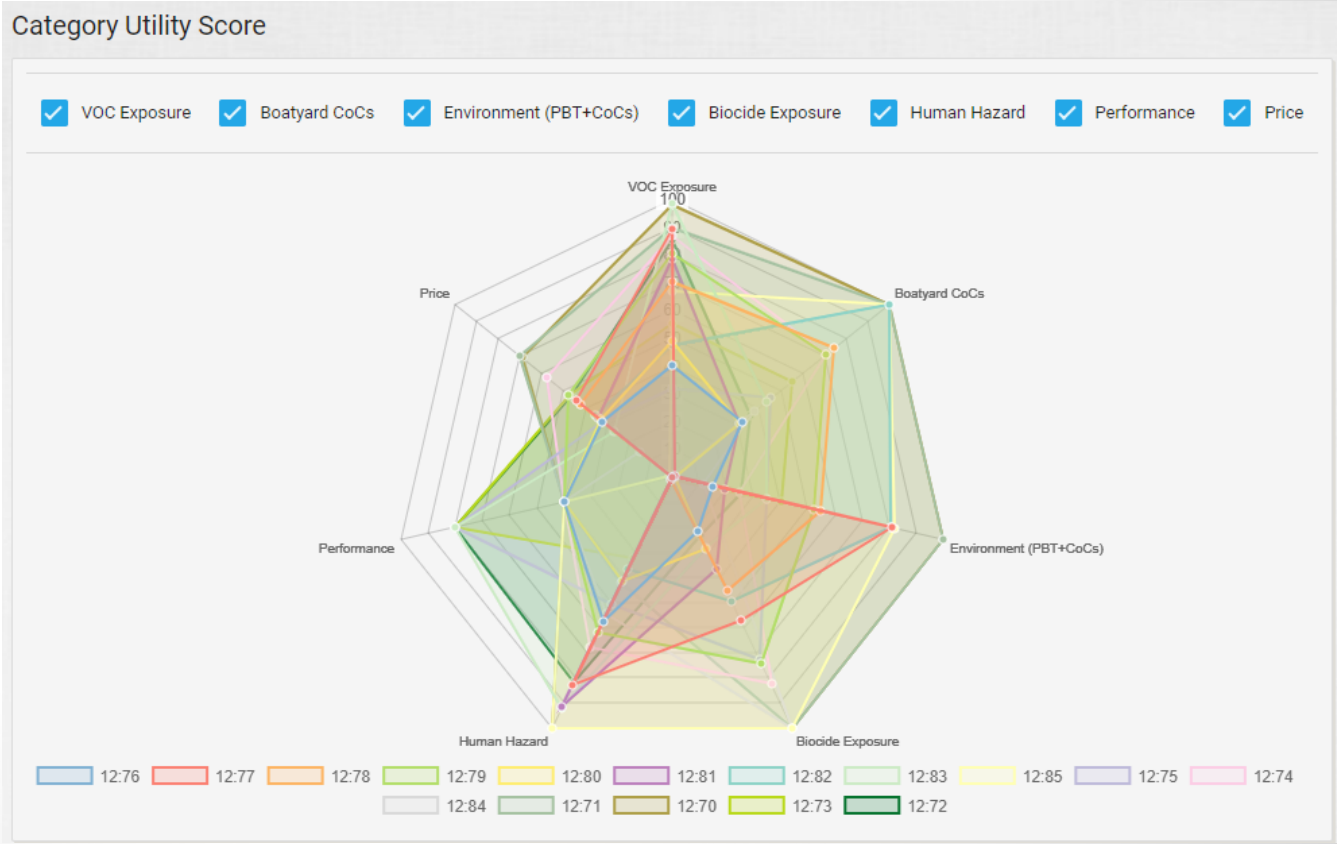


Results based on User Preference

Dataset	Green Consumer	Average consumer	All Equal	user_test
12:76	14	10	15	12
12:77	7	9	8	13
12:78	15	13	13	15
12:79	5	6	5	8
12:80	16	11	16	11
12:81	11	15	12	14
12:82	10	14	9	16
12:83	4	8	6	3
12:85	2	12	3	9
12:75	9	7	10	5

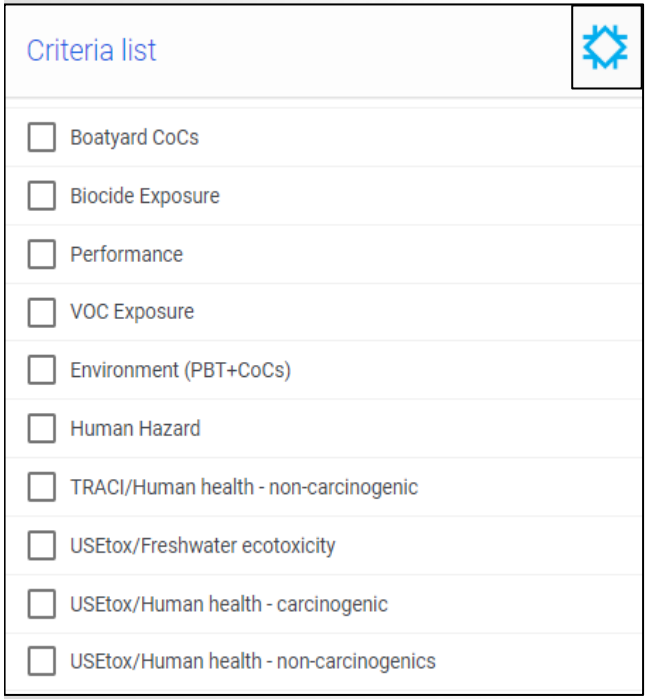
Assessing Trade-offs

- Offers user-friendly interface
- Provides visualization of comparative results
- Allows testing of “what-if” scenarios
- Can assess impact of selected factors



Data Sources

Hazard



Exposure

ConsExpo
consumer | exposure

PubChem

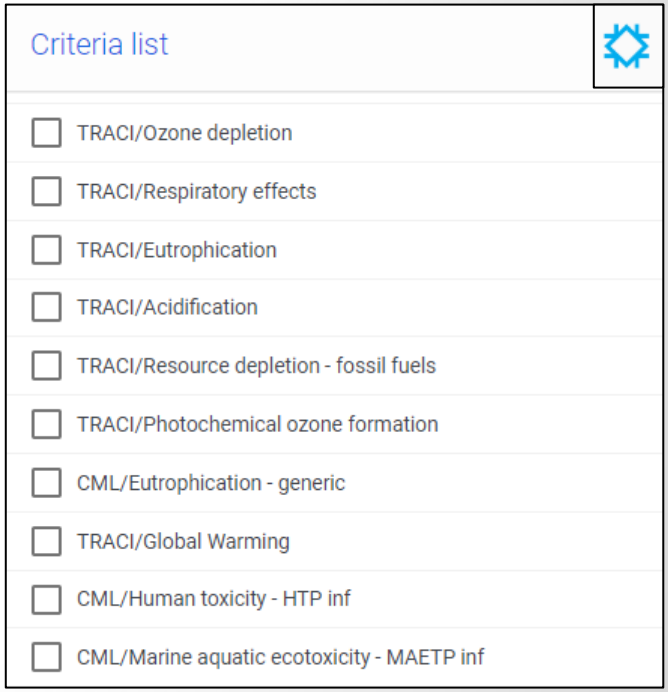
LCA

ecoinvent

USEtox®

TRACI
Tool for the Reduction and Assessment of Chemical and other environmental Impacts

Economic



Potential Users

Material Resource Credits

Integrative Analysis	Mfg	Install	Use	Maintain	End of Life
Human Health					
Envir'l Impacts					
Safety					

Tool Providers

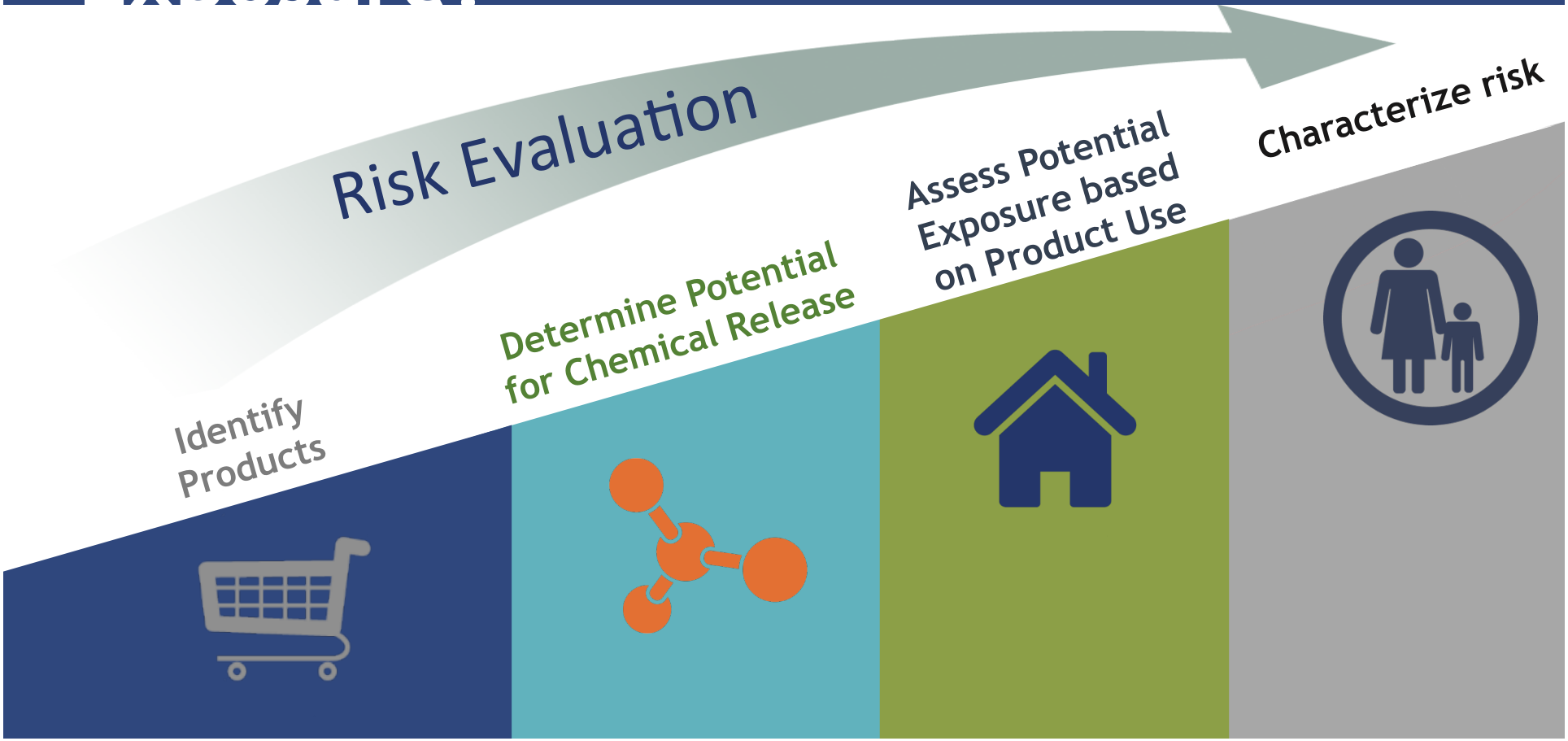
e.g., toxnot, UL, SciVera, CPA, Verisk 3E

Education / Communication

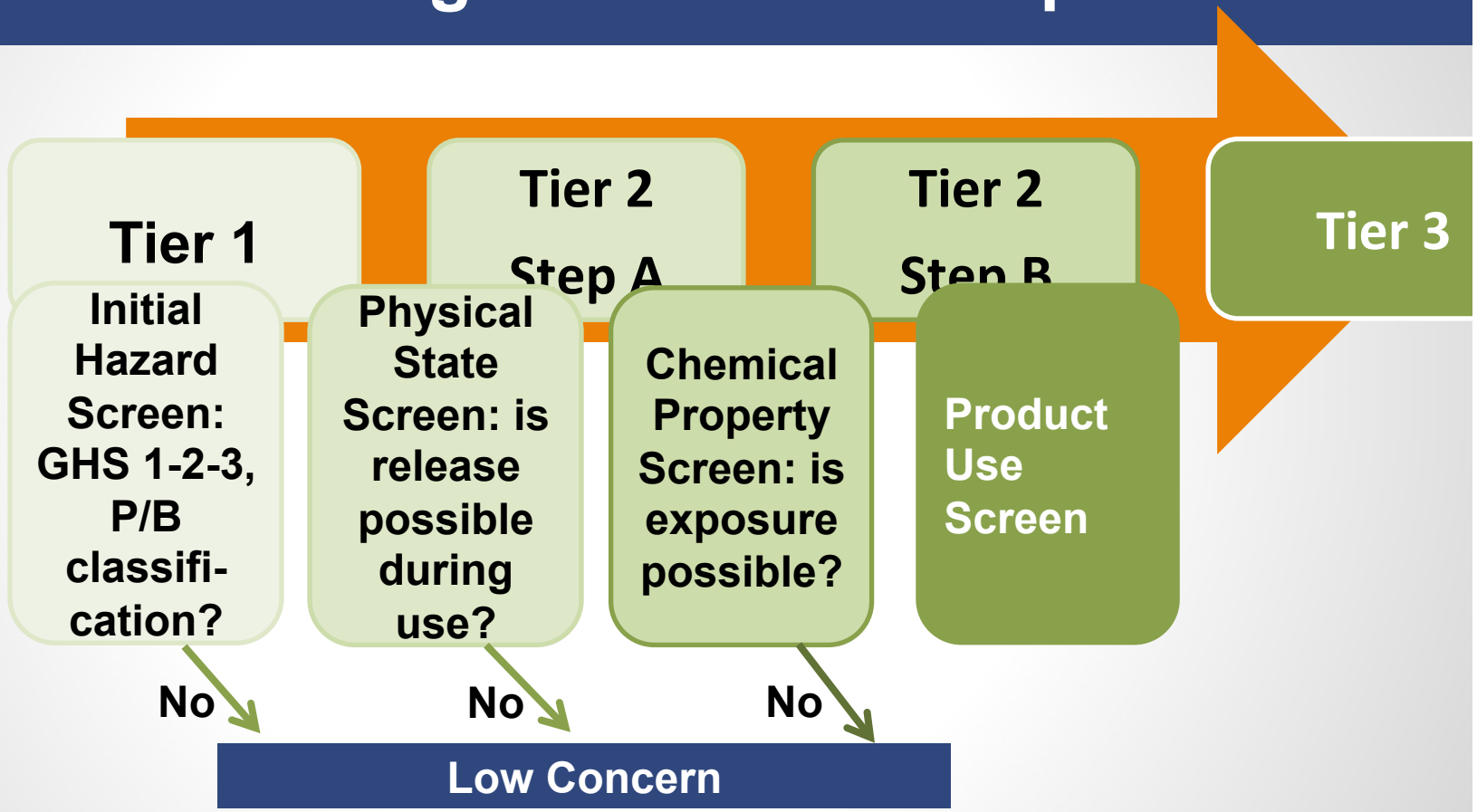
- Make MCDA Operational
- Assess Trade-Offs
- Identify Data Sources
- Solutions for Data Gaps


Tiered
Exposure
Screening
American®
Chemistry
Council

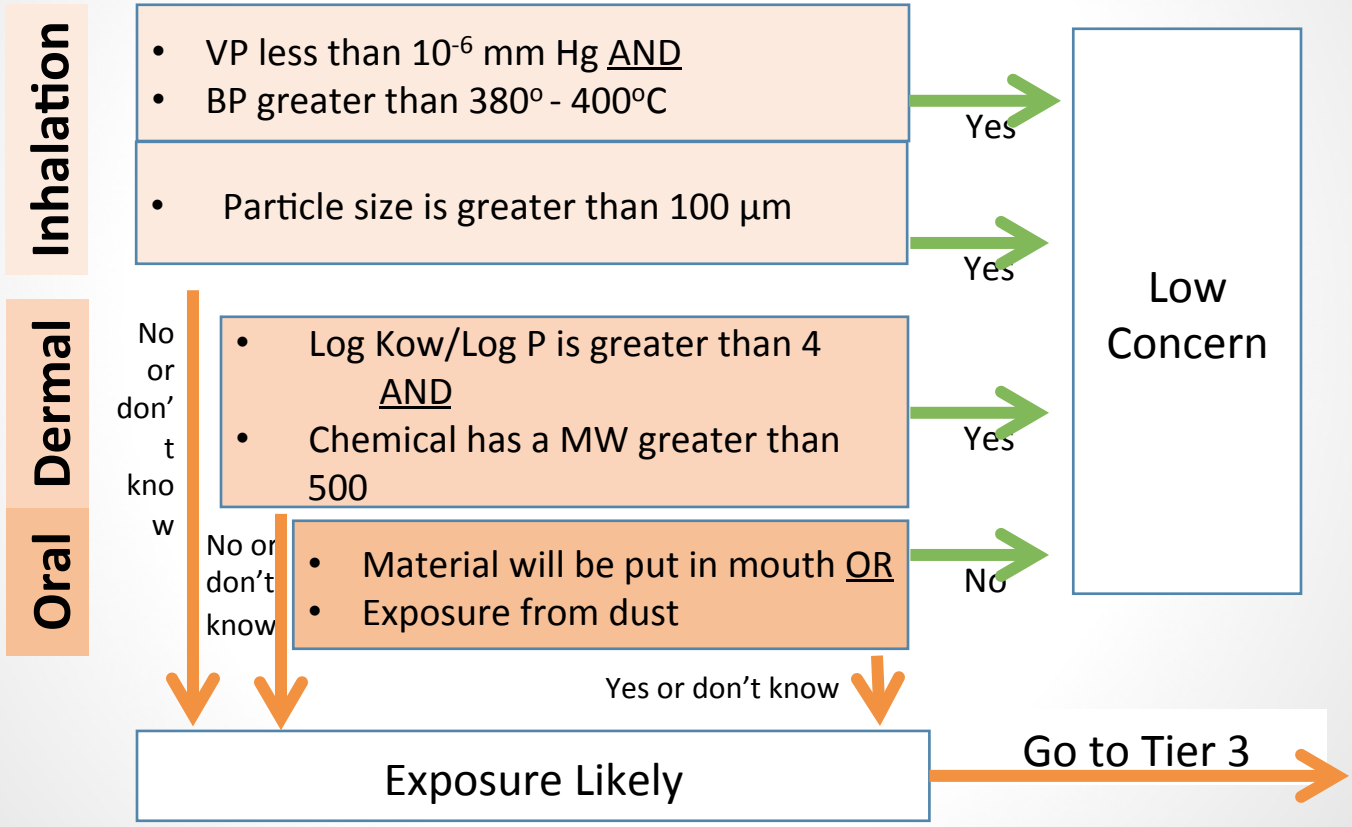
Is There Potential for Release and Exposure?



Tiered Screening for Chemical Exposures



Tier 2 Step B – Chemical Property Screen



Tier 3 - Exposure Subscore

Define Exposure Scenario:

- **Product**
- **Chemical**
- **Route**
- **User**

Exposure criteria/Score	1	2	3	4	Score
User-direct exposure	Professional	Adult	Teen	Child/sensitive population	1 to 4
Product form during use	Solid	Gel/paste (from container)	Liquid (poured, mixed, rolled on)	Aerosol Pressurized container	1 to 4
				Pump (unpressurized container)	
			Pump (non-aerosol)	Powder (crystals, granules)	
Concentration in product	Less than 0.1%	0.1-1%	1-10%	10-100%	1 to 4
Frequency of use	Annually or less	Monthly	Weekly	Daily	1 to 4
Duration of use	<1 minute	1-60 minutes	1-8 hours	8-24 hours	1 to 4
				Exposure Score	5 to 20

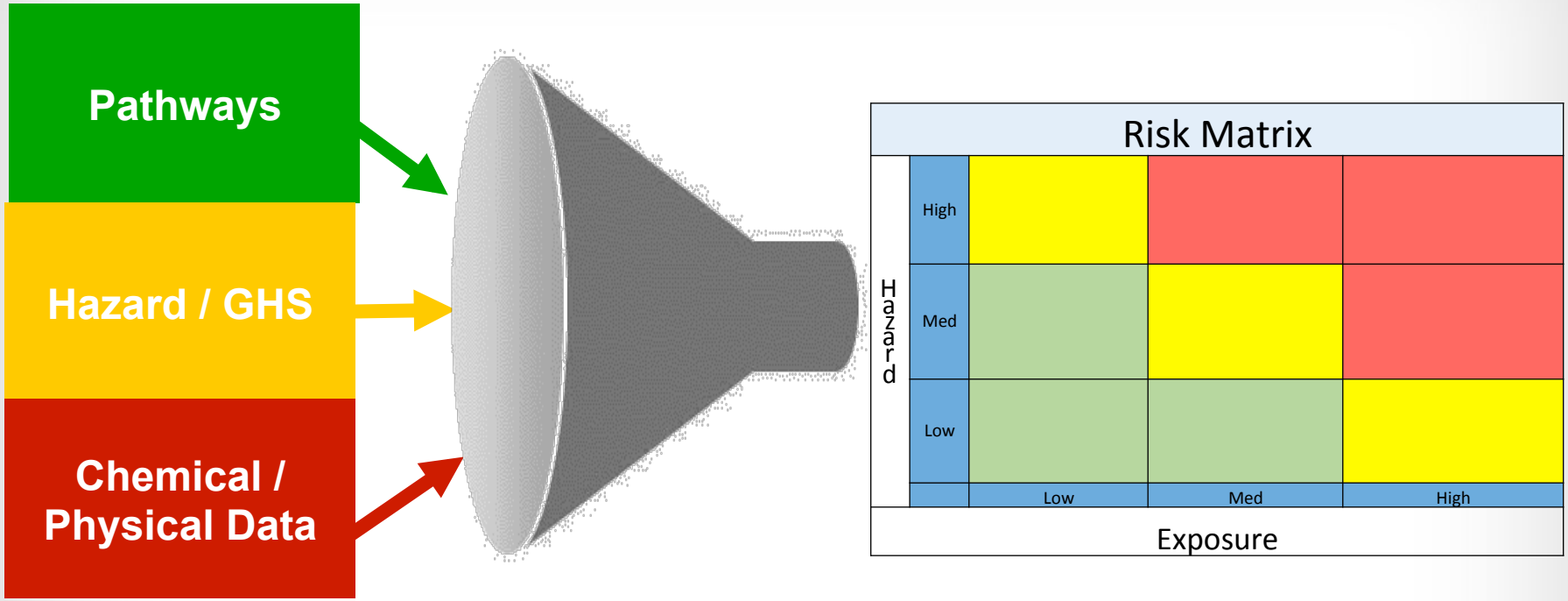
Hazard + Exposure Scoring

	Hazard Sub-score	Exposure Sub-score		
		Low [1] (5 – 9)	Med [2] (10-15)	High [3] (16-20)
Not Carcinogen/mutagen/repro/develop (CMR); AND No GHS classification for Repeat dose; AND No GHS classification for eye/skin irritation; AND Not P or B	Low [1]	2	3	4
Not CMR; AND Repeat dose GHS Cat 3; AND No GHS classification for eye/skin irritation; AND Not P or B	Medium [2]	3	4	5
CMR GHS Cat 2; OR Repeat dose GHS Cat 2; OR Eye Damage/Skin Corrosion GHS Cat 2; OR Respiratory Sensitization GHS Cat 2; OR P *and not* B; OR B *and not* P	Medium-High [3]	4	5	6
CMR GHS Cat 1A, 1B; OR Repeat dose GHS Cat 1; OR Eye Damage/Skin Corrosion GHS Cat 1; OR Respiratory Sensitization GHS Cat 1A or 1B; OR P *AND* B; OR vPvB; OR	High [4]	5	6	7

Pilot Study Key Findings

- Easily implemented
- Produces a concise and transparent stepwise framework
- Uses publicly available data
- Documents key decisions and inputs
- Provides a powerful tool for communicating screening findings to formulators, manufacturers, and stakeholders

Phase 2 Pilot Study



Green: Considered low risk
Yellow: May require further information from the manufacturer or formulator to determine if more detailed risk assessment information can be provided
Red: May require a more rigorous risk assessment; may indicate data gaps; may lead to AA


Questions?