

Alternatives Assessment: The Science of Identifying Safer Substitutes

Webinar for CHANGE

July 20, 2009

Peter Sinsheimer, Ph.D.

UCLA Law and Environmental Health
Sustainable Technology Policy Program

Webinar Overview

- Background on Alternatives Assessment
- AB998 Requirements
- Components of Alternatives Assessment
- Case Studies
 - Formaldehyde: Hardwood Plywood, Structural Use Panels
 - Lead: Wheel Weights
 - Perchloroethylene: Dry Cleaning, Vapor Degreasing, Automotive Aerosols
- Complicating Factors in Conducting AA
- Possible Decision Rules
- Linking AA to Regulatory Response
- Conclusion/Discussion

Personal Background

- Masters in Public Health
 - Epidemiology: Risk factors that cause disease
 - Thesis: Second hand smoke and cardiovascular disease
- Ph.D. Environmental Planning
 - Interest in programs to prevent illness vs. studying exposure
 - Pollution prevention in garment care industry
 - 1 chemical (perchloroethylene) and 1 process (dry cleaning)
 - Alternatives Assessment
 - Identified 2 viable safer substitutes (wet cleaning and CO₂)
 - Phase out of perc dry cleaning in CA
 - Yet, 100,000 chemicals and million uses

Defining Alternatives Assessment

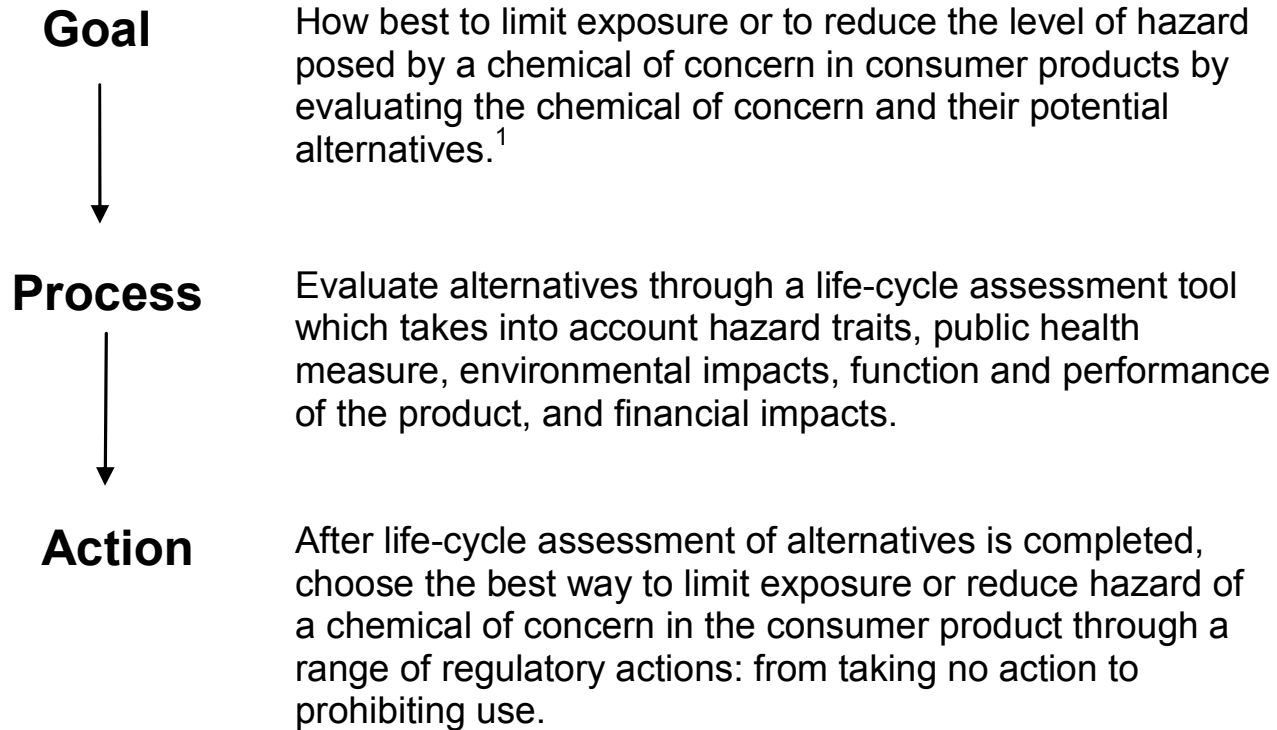
- An analysis of alternatives and opportunities that prevent impacts from potentially harmful activities.

Ken Geiser, 2004

History of Alternative Assessment

- Toxics Use Reduction Institute (Massachusetts)
 - Focus on industry choices
- EPA (US)
 - Cleaner Technology Substitutes Assessment
 - Voluntary
 - TSCA
 - Asbestos
 - EPA ban -- safer alts. Court remand – not properly justified
- Montreal Protocol (International)
 - Mandatory phase out of ozone depleting chemicals
 - SNAP → EPA program
- REACH (EU)
 - Evaluation of safer substitutes
 - Allows firm to manage risks even when substitutes available

Structure of AB1879

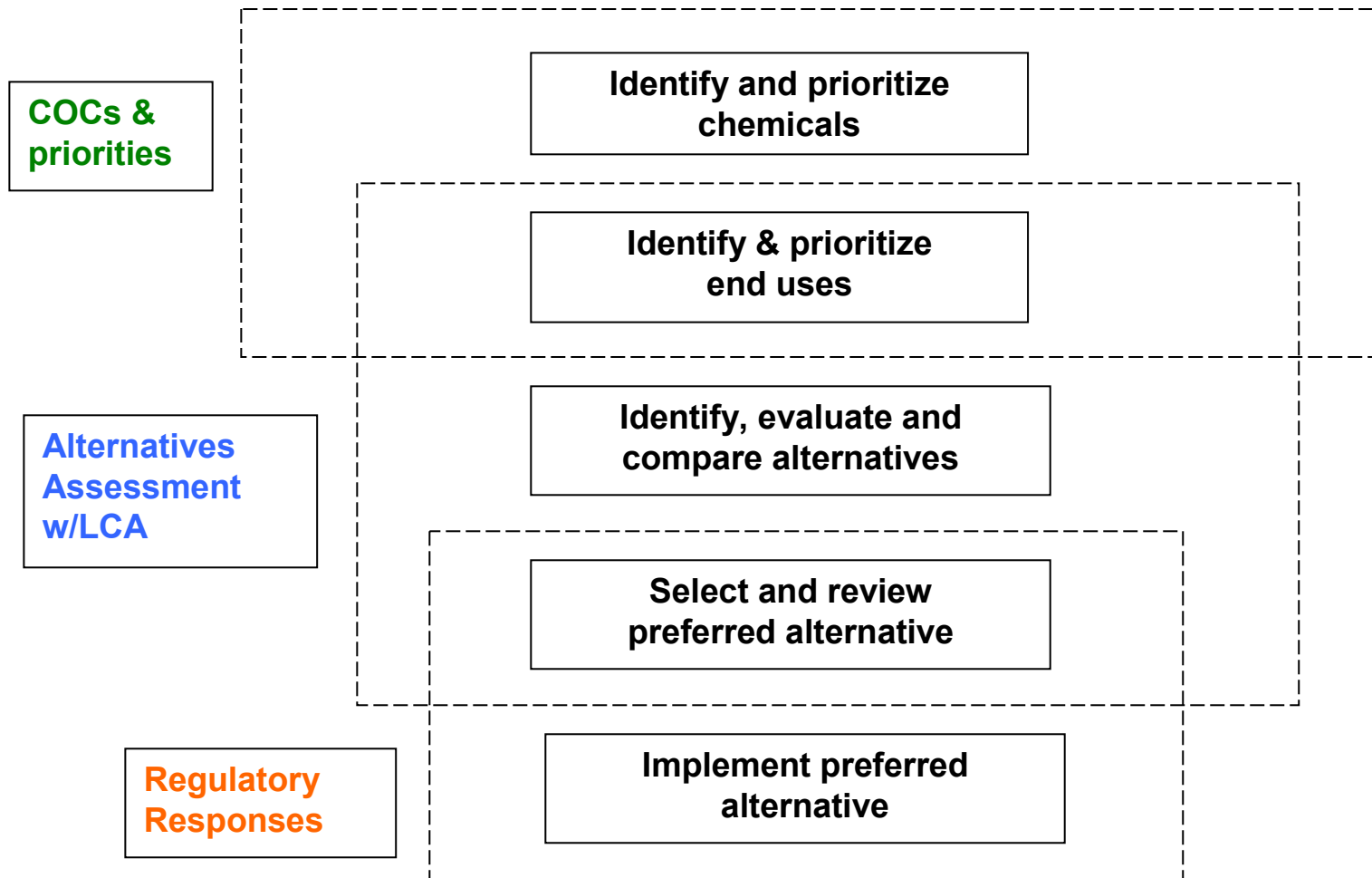


¹. SB509: “Consumer product” means a product or part of the product that is used, brought, or leased for use by a person for any purposes.

Critical Dates to Establish Method

Subject	Content	Date
Chemicals of Concern	Adopt regulations to establish a process to identify and prioritize those chemicals or chemical ingredients in consumer products that may be considered as being a chemical of concern.	On or before January 1, 2011
Alternatives Assessment & Regulatory Response	Adopt regulations that establish a process for evaluating chemicals of concern in consumer products, and their potential alternatives, to determine how best to limit exposure or to reduce the level of hazard posed by a chemical of concern.	On or before January 1, 2011

AB1879 Implementation



AB1879: Opportunities and Opportunities to Fail

- Opportunities
 - Covers all chemicals in commerce.
 - Authority to phase out CoC use when safer alternatives identified.
 - Capable of spurring innovation of safer substitutes.
- Challenges
 - Statute does not provide guidance on how to conduct alternative assessment.
 - Statute does not provide guidance on appropriate regulatory response.
 - No funding in statutes for implementation.
 - If 2011 regulations not properly formulated, could be counter-productive. Chemical by chemical bills may be better.

AB1879

List of Alternatives Assessment Measures

“The regulations adopted pursuant to this section shall establish a process that includes an evaluation of the availability of potential alternatives and potential hazards posed by those alternatives, as well as an evaluation of critical exposure pathways. This process shall include life cycle assessment tools that take into consideration, but shall not be limited to, all of the following:

- (A) Product function or performance.
- (B) Useful life.
- (C) Materials and resource consumption.
- (D) Water conservation.
- (E) Water quality impacts.
- (F) Air emissions.
- (G) Production, in-use, and transportation energy inputs.
- (H) Energy efficiency.
- (I) Greenhouse gas emissions.
- (J) Waste and end-of-life disposal.
- (K) Public health impacts, including potential impacts to sensitive subpopulations, including infants and children.
- (L) Environmental impacts.
- (M) Economic impacts.”

Alternatives Assessment Criteria and AB1879 Requirement

Alternatives Assessment Criteria	AB1879: Section 25253 (a) (2)
Human Health & Public Safety	<ul style="list-style-type: none"> • Potential hazards posed by those alternatives (Sec. 2). • Critical exposure pathways (Sec 2). • Public health impacts, including potential impacts to sensitive subpopulations, including infants and children (K).
Environmental Impact	<ul style="list-style-type: none"> • Materials and resource consumption (C). • Water conservation (D). • Water quality impacts (E). • Air emissions (F). • Production, in-use, and transportation energy inputs (G). • Energy efficiency (H). • Greenhouse gas emissions (I). • Waste and end-of-life disposal (J). • Environmental impacts (L).
Technical Performance	<ul style="list-style-type: none"> • Product function or performance (A).
Cost	<ul style="list-style-type: none"> • Economic impacts (M). • Useful life (B).

Human Health Criteria

CoC Use

Measure	Yes/No	Strength of Association
Chronic Effects		
• Carcinogen	√	√
• Mutagen	√	√
• Repro toxicity	√	√
• Immunotoxic	√	√
• Endocrine disruptor	√	√
• Cardiovascular	√	√
• Etc		
Acute		
• Allergen	√	√
• Ocular hazards	√	√
• Irritant	√	√
• Etc		
Occupational exposure limit	√	√
Sub-population	√	

Alternative

Measure	Yes/No	Strength of Association
Chronic Effects		
• Carcinogen	√	√
• Mutagen	√	√
• Repro toxicity	√	√
• Immunotoxic	√	√
• Endocrine disruptor	√	√
• Cardiovascular	√	√
• Etc		
Acute		
• Allergen	√	√
• Ocular hazards	√	√
• Irritant	√	√
• Etc		
Occupational exposure limit	√	√
Sub-population	√	

Human Health Data

Methods

- Epidemiology
- In vivo – animal testing
- In vitro – test tubes/Petri dish
 - High throughput bioassays
- Structure activity relationship
- Variety of test methods for each
- Meta-analysis to resolve differences

Expertise

- Toxicology
- Chemistry
- Molecular Biology

Environmental Criteria

CoC Use

Measure	Yes/No	Strength of Association
Persistent, bioaccum and toxic (PBT)	√	√
vPvB	√	√
Aquatic/Eco toxicity	√	√
Biodegradability	√	√
Water use	√	√
Water quality	√	√
Ozone depletion	√	√
Greenhouse gas	√	√
Hazardous Air Pollutant	√	√
Smog-forming	√	√
Energy use	√	√
End-of-life disposal	√	√

Alternative

Measure	Yes/No	Strength of Association
Persistent, bioaccum and toxic (PBT)	√	√
vPvB	√	√
Aquatic/Eco toxicity	√	√
Biodegradability	√	√
Water use	√	√
Water quality	√	√
Ozone depletion	√	√
Greenhouse gas	√	√
Hazardous Air Pollutant	√	√
Smog-forming	√	√
Energy use	√	√
End-of-life disposal	√	√

Environmental Data

Methods

- Laboratory tests
- Field tests

- Variety of test procedures for each
- Meta analysis to resolve differences

Expertise

- Biology
- Engineering
- Environmental Science

Performance Criteria

CoC Use

Measure	Yes/No	Rating	Interval
Performance specific to product or process		√	√
Training requirements	√	√	
Maintenance		√	
Durability		√	√
R&D assessment		√	
Potential enhancements		√	
Social utility		√	√

Alternative

Measure	Yes/No	Rating	Interval
Performance specific to product or process		√	√
Training requirements	√	√	
Maintenance		√	
Durability		√	√
R&D assessment		√	
Potential enhancements		√	
Social utility		√	√

Performance Data Sources

Methods

- Laboratory tests
 - Questionnaires
 - Interviews
 - Field tests
 - Industry standard
-
- Variety of test procedures for each
 - Meta analysis to resolve differences

Expertise

- End user
- Engineering
- Chemistry
- Material Science

Economic Impact Criteria

CoC Use

Measure	Yes/No	Scale	Interval
Market price			√
Raw material cost			√
Life cycle cost			√
Operating cost			√
Capital equipment cost			√
Relative nominal cost		√	
Economies of scale	√		√
Price sensitivity (material/labor, etc)		√	√

Alternative

Measure	Yes/No	Scale	Interval
Market price			√
Raw material cost			√
Life cycle cost			√
Operating cost			√
Capital equipment cost			√
Relative nominal cost		√	
Economies of scale	√		√
Price sensitivity (material/labor, etc)		√	√

Economic Data

Methods

- Field research
- Interviews with end users and manufacturers

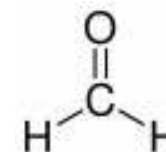
- Variety of procedures for each
- Meta analysis to resolve differences

Expertise

- End user
- Manufacturer
- Economist
- Engineering
- Chemistry

Alternatives Assessment: Formaldehyde Hardwood Plywood Building Panels¹

Assessment Criteria		Formaldehyde-based resin reference	PureBond soy-based adhesive
Human Health	Carcinogen in Resin	Yes	+
	Toxic Intermediate in Resin	Yes	=
	Irritant in Resin	Yes	+
Enviro	Ecotoxicity	Minor	=
Technical	Appearance/ Construction	ANSI/HVPA HP-1-2004	=
	Glue bond under moisture	Good (ANSI 3-cycle soak)	=
		Poor (ANSI 3-cycle boil)	+
	Fire Resistance	Good (ASTM E-85 Flame Spread Class C)	=
	Warp Resistance	Variable	=/?
Product Availability	Good	=	
Financial	Cost (1/2 in. 4x8)	\$1.25/ft ² (Columbian's price)	=



Comparison Key: Alt to CoC + Better = Similar – Worse ? Unknown

¹ TURI: Five Chemicals Alternatives Assessment Study, 2006.

Alternatives Assessment: Formaldehyde Structural Use Building Panels¹

Assessment Criteria		Softwood Plywood with formaldehyde-based resin (Reference)	Comparison Relative to formaldehyde-based resin Softwood Plywood and OSB	
			Homasote	Viroc
Human Health	Carcinogen in Binder	Yes	+	+
	Irritant in Binder	Yes	+	=
Enviro	Ecotoxicity	Minor	+	+
	Natural Resource Conservation	Poor	+	?
	Energy Intensity	Neutral	?	-
Technical	Weight (1/2 in) lb/ft ²	Acceptable	+	-
	Fire Resistance	Good (Class C)	=	+
	Insect/Rot/Mold Resistance	Acceptable	+	+
	Load bearing/weight	Good	-	-
	Impact Resistance	Good	-	+
	Tensile Strength (lb/in ²)	Excellent	-	-
	Shear	Good	+	
	Permeance	Acceptable	+	+
	Linear Expansion (50-90% RH)	Good	-	+
	“Weatherability”	Acceptable	?	?
	Nail Pull (Dry)	50 lbs	+	+
	R Value	.6	+	-
Financial	Cost (1/2 in. 4x8)	\$14	-	-



¹ TURI: Five Chemicals Alternatives Assessment Study, 2006.

Alternatives Assessment: Lead Wheel Weights¹



Assessment Criteria		Lead Reference	Copper	Steel	Tin	Zinc
Human Health	Carcinogenicity	EPA B2	+	+	+	+
	Repro/D.Tox	IARC 2B	+	+	+	+
	Occup. Exposure	0.05 mg/m ³	+	+	+	+
Enviro	Drinking Water	15 g/L	+	+	+	?
	Aqu Tox (Freshwater)	65 g/L	-	+	?	+
	Aqu Tox (Saltwater)	210 g/L	-	?	?	-
Technical Performance	Density	11.34 g/cm ³	-	-	-	-
	Malleability	Good	=	-	=	-
	Corrosion Resistance (with coating)	Good	=	=	+	=
Cost	Price per weight (coated, ½ -2 oz)	\$0.25-\$0.43	-	=/+	-	=
	Available in clip-on & adhesive styles	Yes	-	=	-	=
	End-of-life Costs (Auto Shredder)	Average	+	+	+	+

¹ TURI: Five Chemicals Alternatives Assessment Study, 2006.

Alternatives Assessment: Perchloroethylene Dry Cleaning¹



Assessment Criteria		PCE Reference	Hydro Carbon	Siloxane	Glycol Ether	Wet Cleaning	CO2
Human Health	Carcinogenicity	2A	+	+	+	+	+
	Mutagenicity	No	=	=	=	=	=
	Repro/D.Tox	No/?	=	=	=	=	=
	Dermal/Oral/Resp.	Irritant	?	+	+	=	=
	Exposure Limits	100 ppm; 25 TLV	+	-	+	+	?
Safety	Flammability	Non-F	-	-	=	=	-
	Reactivity	Non-R	=	=	=	=	=
	Corrosivity	Non-C	=	=	=	=	=
Enviro	Water	60 days	+	+	+	+	+
	Soil	120 days	-	+	+	+	+
	Sediment	540 days	+	+	+	+	+
	Air	98 days	+	+	+	+	-
	BCF	83	-	+	+	+	+
Technical	Time	45 min	-	-	+	-	-
	Load Capacity	60 lbs	-	+	=	+/-	-
	# of Soils		-	-	=	-/=	=
	Clothing Types		+	=	-	-	+
	Spotting Requirements		-	-	+	-	=/-
Financial	Equipment		-	-	-	+	-
	Solvent		+	?	-	+	?
	Labor		-	?	=	-	?
	Operating		=	?	=	=	?
	Regulatory		+	=	+	+	+

¹ TURI: Five Chemicals Alternatives Assessment Study, 2006.

Alternatives Assessment: Perchloroethylene Dry Cleaning (Revised)

Assessment Criteria		PCE Reference	Hydro Carbon	Siloxane	Glycol Ether	n Propyl Bromide	Wet Cleaning	CO2
Human Health	Carcinogenicity	2A	+	?/=	?	?/=	+	+
	Mutagenicity	No	=	=	=	=	=	=
	Repro/D.Tox	No/?	=	=	=	-	=	=
	Dermal/Oral/Resp.	Irritant	?	+	=	-	=	=
	Exposure Limits	100 ppm; 25 TLV	+	-	?	-	+	+
Safety	Flammability	Non-F	-	-	-	?	=	=
	Reactivity	Non-R	=	=	=	=	=	=
	Corrosivity	Non-C	=	=	=	=	=	=
Enviro	Water	60 days	+	?/-	+	+	+	+
	Soil	120 days	-	?/-	+	+	+	+
	Sediment	540 days	+	?/-	+	+	+	+
	Air	98 days	-	?/-	-	+	+	+
	Energy		-	-	-	?	+	+
	BCF	83	-	+	+	-	+	+
Technical	Time	45 min	-	-	-	=	+	+
	Load Capacity	60 lbs	-	+	-	=	=	=
	# of Soils		-	-	=	=	=	=
	Clothing Types		+	=	+	=	=	=
	Spotting Requirements		-	-	=	=	=	=
Financial	Equipment		-	-	-	+	+	+
	Solvent		+	?	-	=	=	=
	Labor		-	?	=	=	=	=
	Operating		=	?	=	=	+	+
	Regulatory		+	=	+	?	+	+

Alternatives Assessment: Perchloroethylene Vapor Degreasing Drop-In Alternatives¹

Assessment Criteria		PCE Reference	NPB	Silicone	HFC1	HFC2
Human Health	Carcinogenicity	2A	?	?	+	+
	Mutagenicity	No	?	?	=	=
	Repro/D.Tox	No/?	-	?	=	=
	Dermal/Oral/Resp.	Irritant	=	=	=	=
	Exposure Limits	100 ppm; 25 TLV	-	+	?	?
Safety	Flammability	Non-F	-/=	-	=	=
	Reactivity	Non-R	=	=	-	-
	Corrosivity	Non-C	=	=	=	?
Enviro	Water	60 days	+	+	-	-
	Soil	120 days	+	+	-	-
	Sediment	540 days	+	+	-	-
	Air	98 days	+	+	-	-
	BCF	83	+	-	-	-
Technical Performance	Vapor Pressure	15.8 mm Hg	-	-	-	-
	Latent Heat	50.1 cal/g	-	-	+	+
	Boiling Point	121 C	+	+	+	+
	Flash Point	None	=	-	=	=
	Surface Tension	32.3 dyne/cm	+	+	+	+
	KB Value	90	+	+	-	-
	Performance	Effective	=	=	=	=
Cost	Purchase		-	-	-	-
	Energy		+	=	+	+



¹ TURI: Five Chemicals Alternatives Assessment Study, 2006.

Alternatives Assessment: Perchloroethylene Brake Cleaning Alternatives¹

Assessment Criteria		PCE Reference	Heptane- Brake	Hydro carbon- Brake	Toluene- Brake	Aqueous
Human Health	Carcinogenicity	2A	+	+	+	+
	Mutagenicity	No	=	=	-	=
	Repro/D.Tox	No	=	=	-	=
	Dermal/Oral/Resp.	Irritant	=	=	=	+
	Exposure Limits	100 ppm; 25 TLV	+	+	+	+
Safety	Flammability	Non-F	-	-	-	=
	Reactivity	Non-R	=	=	-	=
	Corrosivity	Non-C	=	=	=	=
Enviro	Water	60 days	+	+	+	+
	Soil	120 days	+	=	+	+
	Sediment	540 days	+	+	+	+
	Air	98 days	=	+	=	+
	BCF	83	-	-	+	+
Technical Performance	Cleaning	Effective	=	=	=	=
	Fiber control	Unknown	-	?	?	?
	Drying	Quick	?	=	?	-
	Residue	None	?	=	=	-
	Flammable	Non	-	-	=	=
Cost	Purchase		+	=	-	+



¹ TURI: Five Chemicals Alternatives Assessment Study, 2006.

Complicating Factors in Determining Viability of Alternatives

Complicating Factors	Example	Notes
Weighting intensity of a measure	Vapor degreasing Workplace TLV: <ul style="list-style-type: none"> • Perc=25 ppm • nPB=10 ppm 	<ul style="list-style-type: none"> • Useful for screening criteria and determining overall viability.
Weighting relative importance of measures and criteria.	Vapor degreasing <ul style="list-style-type: none"> • Perc, nPB: Health bad • HFC: Air bad (ozone depletion) 	<ul style="list-style-type: none"> • Useful for screening criteria and determining overall viability. • Could be quantitative or qualitative.
Unknown data for any measure.	Lead wheel weights <ul style="list-style-type: none"> • Steel: Aquatic toxicity 	<ul style="list-style-type: none"> • Weighing uncertainty for screening, viability of a category and technology.
Mixed results within criteria – e.g. better, worse, unknown.	Formaldehyde structural panels <ul style="list-style-type: none"> • Homasote performance 	<ul style="list-style-type: none"> • Necessary if determining overall viability of criteria and technology
Conflicting data within a measure.	Formaldehyde plywood <ul style="list-style-type: none"> • Soy alt – warp resistance 	<ul style="list-style-type: none"> • Meta-analysis.
Multiple alternatives, with some viable and superior to others on health and environmental factors.	Perc dry cleaning <ul style="list-style-type: none"> • Wet cleaning and CO2 superior • Petroleum, etc 	<ul style="list-style-type: none"> • How to deal with sub-optimal alternatives.
Social utility	Formaldehyde structural panels <ul style="list-style-type: none"> • Social utility high and no apparent viable alternatives 	<ul style="list-style-type: none"> • How to deal with CoC use when social utility low and no viable alts available.
Multiple CoC within a particular product or process.		<ul style="list-style-type: none"> • Need to develop specific methods.
Many methods for determining overall viability		<ul style="list-style-type: none"> • Many weighting, screening, and scoring methods. Methods can determine outcome.

Procedures for Determining Viability of Alternatives

- Screening
 - Qualitative comparison of measures or criteria.
- Weighting
 - Quantitative assessment of importance of measures or criteria.
 - Ex: Measure: Carcinogen vs. irritant
 - Ex: Criteria: Human health vs. cost
 - Social utility can be used as part of the weighting process.
- Scoring
 - Quantitative assessment of criteria, measure, or overall technology.

Possible Decision Rules

Establishing Viability of Alternatives

- Option 1: If alternative has at least one measure for human health positive (+) and all other measures from other categories positive (+) or equal (=):
 - Then alternative classified as a viable safer substitute.

Ex: Perchloroethylene dry cleaning: Professional wet cleaning alternative.

- Option 2: If alternative has at least one measure for human health positive (+), all other measures from human health and environmental categories at least equal, and at least one measure from performance or cost negative or uncertain:
 - Then evaluate further or weigh importance of this measure before determining viability of the alternative.

Ex: Formaldehyde plywood panels: Pure-Bond soy-based alt: Performance (warp).
Lead wheel weights: Steel alt: malleability and density.

AB 1879: Linking Alternatives Assessment Results to Regulatory Response

- Statute links alternatives assessment evaluation to regulatory response
 - “(A)dopt regulations that establish a process for evaluating chemicals of concern in consumer products, and their potential alternatives, to determine how best to limit exposure or to reduce the level of hazard posed by a chemical of concern.”
 - Since statute requires the evaluation of alternatives, more likely an alternative is viable, the stronger the regulatory response should be in promoting its use.

AB1879

List of Regulatory Response Options

(b) The regulations adopted pursuant to this section shall specify the range of regulatory responses that the department may take following the completion of the alternatives analysis, including, but not limited to, any of the following actions:

- (1) Not requiring any action.
- (2) Imposing requirements to provide additional information needed to assess a chemical of concern and its potential alternatives.
- (3) Imposing requirements on the labeling or other type of consumer product information.
- (4) Imposing a restriction on the use of the chemical of concern in the consumer product.
- (5) Prohibiting the use of the chemical of concern in the consumer product.
- (6) Imposing requirements that control access to or limit exposure to the chemical of concern in the consumer product.
- (7) Imposing requirements for the manufacturer to manage the product at the end of its useful life, including recycling or responsible disposal of the consumer product.
- (8) Imposing a requirement to fund green chemistry challenge grants where no feasible safer alternative exists.
- (9) Any other outcome the department determines accomplishes the requirements of this article.

AB1879

Proposed Hierarchy of Regulatory Response Options

- (5) Prohibiting the use of the chemical of concern in the consumer product.
- (4) Imposing a restriction on the use of the chemical of concern in the consumer product.
- (6) Imposing requirements that control access to or limit exposure to the chemical of concern in the consumer product.
- (7) Imposing requirements for the manufacturer to manage the product at the end of its useful life, including recycling or responsible disposal of the consumer product.
- (3) Imposing requirements on the labeling or other type of consumer product information.
- (8) Imposing a requirement to fund green chemistry challenge grants where no feasible safer alternative exists.
- (2) Imposing requirements to provide additional information needed to assess a chemical of concern and its potential alternatives.
- (1) Not requiring any action.
- (9) Any other outcome the department determines accomplishes the requirements of this article.

Linking Alternatives Assessment Outcome to Regulatory Response

Alternatives Assessment Outcomes	Regulatory Response
I. Alternative established as viable	<ul style="list-style-type: none"> • For CoC: Prohibiting the use of the chemical of concern in the consumer product. (5) • For Alternative with residual hazard: See below
II. Where: <ul style="list-style-type: none"> • No viable alternative for certain use, or • Alternative viable but with residual hazard, or • III., below 	As appropriate for CoC or alternative: <ul style="list-style-type: none"> • Imposing requirements on the labeling or other type of consumer product information. (3) • Imposing a restriction on the use of the chemical of concern in the consumer product. (4) • Imposing requirements that control access to or limit exposure to the chemical of concern in the consumer product. (6) • Imposing a requirement to fund green chemistry challenge grants where no feasible safer alternative exists. (8)
III. Data missing for complete alternatives assessment	Imposing requirements to provide additional information needed to assess a chemical of concern and its potential alternatives,(2) and, as appropriate, response from II., above
IV. For all CoC and alternatives	As appropriate, imposing requirements for the manufacturer to manage the product at the end of its useful life, including recycling or responsible disposal of the consumer product. (7)

Conclusion

- Alternatives assessment: Scientific process of determining viability of an alternative to a CoC use.
- Problematic for CoC manufacturers/users to conduct alternatives assessment due to inherent conflict of interest.
- Preferable for 3rd party to conduct alternatives assessment.
- Regulations should specify how alternatives assessment should be conducted.
- Regulations should include specific decisions rules to determine viability of alternatives.
- Alternatives assessment outcomes should be explicitly linked in regulation to regulatory response.