Green Chemistry Options for the State of California

A Report from the Green Chemistry Initiative Science Advisory Panel to Department of Toxic Substances Control Director Maureen Gorsen

May 2008

NOTICE

This report was written as part of the activities of the Green Chemistry Initiative Science Advisory Panel. The Panel is a public advisory group structured to provide balanced, expert assessment of scientific matters for the purposes of providing advice to Department of Toxic Substances Control Director Maureen Gorsen on scientific matters pertaining to the advancement of green chemistry. This report has not been reviewed for approval by the Agency; therefore, the contents of this report do not necessarily represent the views and policies of the Department of Toxic Substances Control or the California Environmental Protection Agency. Mention of trade names of commercial products does not constitute a recommendation for use.

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Green chemistry has been called chemistry's approach to creating a sustainable future. Implementing green chemistry techniques can help protect human health and the environment while opening new economic opportunities in the design and use of chemicals, materials, products and processes.

This report is the product of deliberations over the course of seven months by experts in the areas of chemistry, environmental health science, toxicology, chemical production, chemical policy and law, risk and alternatives assessment, human health, exposure assessment, environmental fate, and engineering. While the Panel was not constituted to represent the interests of the full array of stakeholders in chemicals policy, it nevertheless brought together significant expertise from diverse points of view and succeeded in agreeing to advance this final report.

The result is a framework for advancing green chemistry and a collection of options that have been proposed by one or more individuals on the Panel. While many of these options enjoy broad support among the panel members, the degree of support for any single option is neither stated nor implied.

The deliberations resulted in agreement by all members of the panel on one central concept; that is, that the advancement of green chemistry in California is an effective vehicle to promote innovation in ways that also protect human health and the environment and provide new economic opportunities to the people of California.

While strategies to accomplish this goal may differ among the members of the panel, the framework put forward by the Panel outlines the need to affect the behavior of a broad range of actors along three fundamental dimensions to bring about the adoption of green chemistry practices in California:

- Willingness
- Opportunity/motivation
- Capacity

The Panel believes that California can motivate new investment and innovation in green chemistry by addressing existing data, safety, and technology gaps. This will be accomplished through a variety of strategies that affect both the supply of, and demand for, green chemistry (and associated processes, technologies and approaches). Indeed, the Panel acknowledged from the outset that to advance green chemistry, California will need a blend of both supply and demand-side approaches.

Supply-side options – including initiatives in education and research and economic incentives – help to facilitate innovation in green chemistry as applied to products, processes and technologies. **Demand-side options** help to inform the marketplace and promote acceptance of these products, processes and technologies through economic and regulatory policy. Below, we summarize the categories of options described in Sections II and III of the Report.

Science Advisory Panel options on the supply side include those aimed at:

- instilling green chemistry into education (Section II.A.);
- supporting research and innovation in green chemistry and engineering (Section II.B.);
- building green chemistry capacity through development of tools, methodologies and strategies for developing greener chemicals (Section II.C.); and
- providing incentives to industry and recognition of its efforts (Section II.D.)

Panel options on the demand side include those aimed at:

- identifying and prioritizing chemicals or chemical uses of concern (Section III.A.);
- developing, improving and effectively employing regulations (Section III.B.); and
- developing incentives to boost demand for green chemistry (Section III.C.)

Together, these supply and demand strategies are intended to provide California with a broad range of options from which to formulate a comprehensive green chemistry policy.

The Green Chemistry Initiative Science Advisory Panel

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I. The Green Chemistry Initiative Science Advisory Panel

In April 2007, Linda S. Adams, Secretary for Environmental Protection, launched the California Green Chemistry Initiative. The Secretary requested that Department of Toxic Substances Control (DTSC) Director Maureen Gorsen lead a broad public process to generate ideas that could fill information and safety gaps about chemicals, develop overall policy goals, and identify and recommend policy options.

The California Green Chemistry Initiative to date has consisted of two phases. During Phase One, from April to December 2007, participants brainstormed hundreds of green chemistry options. These options were compiled into the Phase One report. Phase Two included three concurrent tracks:

- Draft Frameworks
- Key Elements[1]
- Science Advisory Panel

The Green Chemistry Initiative Science Advisory Panel (Panel) was created in the fall of 2007. This 21-member Panel consisted of leading thinkers and proponents of green chemistry. Panel member are experts in chemistry, chemical engineering, environmental law, toxicology, public policy, pollution prevention and cleaner production, environmental and public health, risk analysis, materials science, nanotechnology, chemical synthesis, and research. This report summarizes the work and work products of the Science Advisory Panel. To read brief biographies of the Panel members, see Appendix A.

A. The Green Chemistry Initiative Science Advisory Panel Process

In order to organize itself to address the many issues related to advancing green chemistry, the Panel formed five subcommittees, with a sixth "synthesis" subcommittee consisting of the chairs and co-chair of the other five. The five topic areas for subcommittee discussion and green chemistry options development were:

> Subcommittee 1: Advancing Green Chemistry Through Evaluation of Data Needs and Availability, chaired by Drs. William Carroll and Richard Denison;

[1] Part of the Green Chemistry Initiative, the "Key Elements" are concepts that recurred throughout the array of options presented in Phase One. They are: disseminate information on toxic chemicals and empower consumers to make informed choices; account for chemical toxicity and impacts in state procurement decisions; train a new generation of scientists and engineers; include Green Chemistry principles in an Environmental Education Initiative; strengthen consumer protection laws; and expand California's pollution prevention program. See http://www.dtsc.ca.gov/PollutionPrevention/GreenChemistryInitiative/index.cfm

Subcommittee 2: Advancing Green Chemistry Through Alternatives Assessment, chaired by Drs. Nicholas Ashford and Michael Dourson;

Subcommittee 3: Advancing Green Chemistry Through Evaluation of Incentives and Barriers, chaired by Dr. Daryl Ditz with assistance from Dr. William Carroll;

Subcommittee 4: Advancing Green Chemistry Through Education and Information Dissemination, chaired by Dr. Ken Geiser; and

Subcommittee 5: Advancing Green Chemistry Through Science and Technology, chaired by Dr. Paul Anastas.

Each subcommittee met over the life of the Panel to develop background material, reports, and options to advance green chemistry in California. The Panel met twice in San Francisco, in order to work together, and to hear comments from the public. (Those comments are cataloged in the meeting notes, in Appendix E.)

As the Panel reached the end of its work, the "Synthesis Committee," led by Panel Chair Dr. John Warner, worked to align the options developed and prepare this final report. It is important to note that while there was substantial agreement on many of the options developed by the subcommittees, the Science Advisory Panel did not attempt to reach consensus on the options developed for presentation to Director Gorsen. Therefore, **this report presents a range of options the Science Advisory Panel has identified for the state to consider. These options can work together to advance green chemistry in California; no single option or category of options is likely to suffice. Rather, the state needs to draw from all of the policy instruments available to it, and assemble and utilize a full and diverse set of options, if it is to create both supply and demand for green chemistry, bridge key gaps hindering current efforts, and effectively carry out the core functions of a comprehensive chemicals policy.**

Special Note: Each of these options was developed by one or more individual members of the Science Advisory Panel. Neither any individual option nor any combination of options should be regarded as representing the consensus of the Science Advisory Panel.

Mission & Vision of the Green Chemistry Initiative Science Advisory Panel

Vision
The State of California has a chemicals policy in place that protects the health of Californians and the environment. The policy assists Californians to:

• implement strategies to stimulate a green chemistry industrial revolution to drive technological innovation and the development of safer, healthier, and more sustainable chemicals, products and processes and approaches across their life cycles.

• move from a system where materials are on a one-way trip from the cradle to grave to a system where products are recovered as raw material for reuse in new products and processes without harming human health or the environment.

• develop strategies to encourage the use of less-hazardous products, processes and approaches by encouraging the use of less-hazardous alternatives.

• motivate and support new investments in safer and more sustainable products, processes and approaches.

California has an unprecedented opportunity to establish new mechanisms to promote economic development while protecting human health and the environment. In order to accomplish this, all stakeholders must be represented and their concerns and issues heard. As an advisory panel of diverse backgrounds, we will strive to articulate to the DTSC various opportunities and issues from multiple perspectives, so that the agency may move forward in its work. We will be sure to identify concepts on which there is consensus. Where there are differing opinions, we will make every effort to represent the various viewpoints in a fair and honest way.

Mission
The Mission of the Green Chemistry Initiative (GCI) Science Advisory Panel is to advise Department of Toxic Substances Control Director Maureen Gorsen on scientific and technical matters in support of the goal of the GCI to significantly reduce adverse health and environmental impacts of chemicals used in commerce, as well as overall costs to California society, by encouraging the redesign of products, manufacturing processes and approaches. The panel will assist Director Gorsen in developing green chemistry and chemicals policy recommendations, and will ensure that these recommendations are based on a strong scientific foundation. The initiative is broad in scope and will consider a wide range of options, in an effort to identify the most effective means of strengthening California's use of green chemistry.

I. B. Green Chemistry: History and Concepts

In their 1998 book, *Green Chemistry: Theory and Practice*, Science Advisory Panel members Paul T. Anastas and John C. Warner defined "green chemistry" as:

> …the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products.

The science of green chemistry addresses pollution prevention at the molecular level. Over the past decade or so, the field of mechanistic toxicology has made significant advances. While our understanding of the molecular structure-activity relationships that control impacts of molecules on human health and the environment is far form complete, there are many general relationships that have been discovered and explored. It can be expected that knowledge in mechanistic toxicology will continue to grow and expand in the future.

The principles of green chemistry serve to link this structural and mechanistic understanding of hazard with scientists who design and invent chemical products and processes. By following these principles, scientists can design materials that are inherently less hazardous.

In order for a technology to be legitimately considered "green chemistry," it must be practically applicable for commercial use. Therefore, in addition to the reduction of hazard, the technology must demonstrate appropriate product performance and economics. Green chemistry, as the molecular science component of sustainability, seeks to create products that simultaneously protect human health and the environment while being consistent with sustainable economic development.

Sadly, safer alternatives have not yet been invented for many hazardous materials currently used in society. One part of the larger effort to create a sustainable future for society must focus on promoting the innovation of green technologies. At present, undergraduate and graduate degree programs in chemistry and materials sciences at our colleges and universities do not require any formal training on the human health and environmental impacts of chemicals. The absence of this knowledge creates a workforce that is unprepared to meet society's demand for safer alternatives.

To better understand the options presented in this report, it is important to define "green chemistry" and its relationship to s concepts. The term "green chemistry" can be defined as "the invention, design, and application of chemical products and processes to reduce or to eliminate the use and generation of hazardous substances."[2] It should be noted, however, that the International Union of Pure and Applied Chemistry (IUPAC), and a number of other organizations and corporations, use the term "sustainable chemistry" to define the same concept. Nonetheless, this highlights an important departure from previous practice in that it demands regulation of downstream impact as well as of processes and materials used. Green engineering, as defined by the United States Environmental Protection Agency (U.S. EPA), is the "design, commercialization, and use of processes and products that are feasible and economic while minimizing the risk to human health and the environment and the generation of pollution at the source."[3, 4]

Life cycle thinking is essential to both green chemistry and green engineering and should be differentiated from the useful life cycle assessment and life cycle

Anastas' & Warner's 12 Principles of Green Chemistry

1. Prevent waste rather than treating it or cleaning it up.

2. Incorporate all materials used in the manufacturing process in the final product.

3. Use synthetic methods that generate substances with little or no toxicity to people or the environment.

4. Design chemical products to be effective, but reduce toxicity.

5. Phase out solvents and auxiliary substances when possible.

6. Use energy efficient processes, at ambient temperature and pressure, to reduce costs and environmental impacts.

7. Use renewable raw materials for feedstocks.
8. Reuse chemical intermediates and blocking agents to reduce or eliminate waste.

9. Select catalysts that carry out a single reaction many times instead of less efficient reagents.
10. Use chemicals that readily break down into innocuous substances in the environment.

11. Develop better analytical techniques for real-time monitoring to reduce hazardous substances.

12. Use chemicals with low risk for accidents, explosions, and fires.

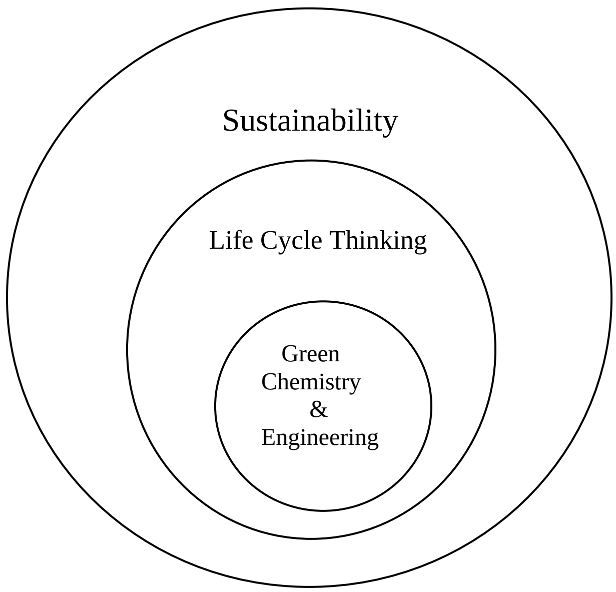
[2] P. T. Anastas and J. C. Warner. Green Chemistry: Theory and Practice. Oxford Science Publications, Oxford (1998).

[3] http://www.epa.gov/oppt/greenengineering/

[4] In this report, "greener" means "conforming to or derived from the principles of green chemistry and engineering."

analysis tools that have been developed to carefully consider the overall impacts of chemicals and technologies over the history of their development, production, use and disposal. Finally, it is important to understand that all of these terms have been incorporated into the broader, global commitment to sustainability and sustainable development. Indeed, it has been noted that green chemistry is the chemistry field's response to creating a sustainable future.

A simple nested graphic describes the conceptual distinctions among these terms.



Finally, "green chemistry and engineering" is not meant to include end-of-pipe approaches, the provision of personal protective equipment, and the like.

I. C. The Need for a Green Chemistry Initiative in California

Despite landmark environmental and occupational legislation in the 1970s, including passage of the federal Toxic Substances Control Act (TSCA) in 1976, many experts have concluded that chemicals policy in the U.S. has not been sufficiently protective of human health or the environment, nor has it promoted innovation in the chemicals market[5] There continue to be substantive gaps in

[5] United States Government Accountability Office. Chemical Regulation: Options Exist to Improve EPA's Ability to Assess Health Risks and Manage its Chemicals Review Program. (http://www.gao.gov/new.items/d05458.pdf) Washington, D.C.: U.S. Government Printing Office, 2005

Goldman L. Preventing Pollution? U.S.Toxic Chemicals and Pesticides Policies and Sustainable Development. Environmental Law Review 32:11018-11041(2002).

understanding about the health and environmental effects for the great majority of the 83,000 chemical substances listed in the TSCA Inventory[6] The U.S. EPA's voluntary High Production Volume Challenge[7] has made limited progress in improving information on chemicals produced or imported at more than one million pounds per year.[8] Since 1979, however, more than 20,000 new substances have been added to the TSCA Inventory, despite very little information about their health or environmental effects.[9] Global chemical production, meanwhile, continues to grow at about 3% per year, doubling every 25 years[10]

Many of these substances come in contact with people – in the workplace, in homes, through the use of products, and through air, water, food and waste streams – and many of them enter the earth's finite ecosystems at some point during their lifecycle. The hazardous properties of industrial chemicals and chemical products are thus of great importance to policymakers, state regulators, and the public at large.

Policy gaps

A 2006 University of California report commissioned by the California Legislature identified three overarching chemicals policy "gaps" that trace their roots to the weaknesses of TSCA and other state and federal laws:[11]

Lempert et al. Next Generation Environmental Technologies: Benefits and Barriers. http://www.rand.org/pubs/monograph_reports/MR1682 (accessed January 2008) Arlington, VA: RAND Corporation (2003)

[6] National Pollution Prevention and Toxics Advisory Committee (NPPTAC), Broader Issues Work Group. How can EPA more efficiently identify potential risks and facilitate risk reduction decision for non-HPV existing chemicals? (2005)(http://epa.gov/oppt/npptac/pubs/finaldraftnonhpvpaper051006.pdf)

[7] U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, High Production Volume (HPV) Challenge (http://www.epa.gov/chemrtk/).

[8] Denison, R.A. (2007) *High Hopes, Low Marks: A final report card on the HPV Challenge*, Environmental Defense Fund, Washington, DC (http://www.edf.org/HPVreportcard).

[9] United States Environmental Protection Agency. Overview: Office of Pollution Prevention and Toxics Programs. Overview, Draft Version 2.0. Washington, D.C. (http://www.chemicalspolicy.org/downloads/TSCA10112-24-03.pdf) pp. 8-11 "The information in PMNs is limited: 67% of PMNs include no test data and 85% include no health data" p. 8 (2003).

[10] The Organization for Economic Cooperation and Development (OECD), UK Chemicals Industry Association and the American Chemistry Council predict an annual growth rate ranging from 0.026 to 0.035 leading up to 2020. Organization for Economic Cooperation and Development (OECD). *Environmental Outlook for the Chemicals Industry* (http://www.oecd.org/dataoecd/7/45/2375538.pdf) p. 34-36 (2001). This is consistent with production trend data from 1992-2002 in American Chemistry Council, *Guide to the Business of Chemistry*, p 78 (2003).

[11] Wilson, Chia, Ehlers. *Green Chemistry in California: A Framework for Leadership in Chemicals Policy and Innovation.* Special Report to the Senate Environmental Quality Committee and Assembly Committee on Environmental Safety and Toxic Materials, California Legislature. University of California, California Policy Research Center, UC Office of the President

The Data Gap

Manufacturers and businesses can sell a chemical or product without generating or disclosing sufficient information about its potential health or environmental hazards.

The Safety Gap

In many cases, public agencies are unable to efficiently gather hazard or exposure information from producers of chemicals, proactively regulate known hazards in an integrated, comprehensive manner, or require producers to accept greater responsibility for the lifecycle impacts of their products.

The Technology Gap

Relative to the pace and scale of chemical production and use, there is insufficient private or public investment in green chemistry research, development, education, and technical assistance.

Implications of the Gaps

In findings that are similar to those of other investigators, the 2006 UC report concluded that the Data, Safety and Technology Gaps have produced a flawed market for chemicals and products in the U.S. in which:

- The health effects of many chemical exposures are poorly understood,
- Hazardous chemicals and products are competitive in the market,
- The majority of the costs of health and environmental damage related to chemical exposures and pollution are carried by the public,
- Broad investment in green chemistry across the chemical industry sector is inconsistent, despite the efforts of leading companies,
- Government has limited authority and information with which to adequately assess the risks of most chemicals in commercial use or control those of greatest concern, and
- There is very little attention given to green chemistry in high school, college or university curricula.

(http://coeh.berkeley.edu/docs/news/06_wilson_policy.pdf) (2006). Thirteen UC faculty provided technical oversight for this report.

In a 2008 report to the California Environmental Protection Agency, the University of California Centers for Occupational and Environmental Health (COEH) at Berkeley and UCLA described several ways in which the weaknesses of TSCA and other federal and state laws are affecting the people and environment of California, including the following:[12]

Workers

In 2004, preventable, chronic diseases resulting from workplace chemical exposures affected about 200,000 Californians; 4,400 died as a result. Safe workplace exposure levels have been established for only 193 (7%) of 3,000 High Production Volume Chemicals.

Children

Over one hundred industrial chemicals have been identified in breast milk and umbilical cord blood, some of which are known to be toxic at low levels; some are increasing in concentration in sampled tissues. Because of the potential health effects of these substances, many of which are incompletely understood, this evidence of exposure among fetuses and infants is of concern.

Environment

About 70% of California's largest hazardous waste sites are leaking toxic material into groundwater. Over 7 billion pounds of plastic waste entered California landfills in 2004, along with nearly one billion pounds of hazardous electronic waste. Plastic waste now outweighs plankton by 6:1 in a swath of the Pacific ocean about twice the size of Texas.

Economy

Occupational diseases attributable to chemical exposures cost $1.4 billion in direct medical costs and indirect costs in 2004, including lost wages and benefits and lost years of productive life. California government spent over $130 million in 2006-07 to manage hazardous waste; groundwater monitoring for toxic substances costs another $30 million annually.

[12] Wilson, Schwarzman, Malloy, Fanning, Sinsheimer. *Green Chemistry: Cornerstone to a Sustainable California* (2008). Report to the California Environmental Protection Agency. University of California, Centers for Occupational and Environmental Health (COEH) at Berkeley and UCLA (http://coeh.berkeley.edu/greenchemistry/briefing/) (2008). 127 UC faculty served as signatories to the final draft of this report.

The 2008 UC report concluded that to address these problems effectively, new policies are needed to close the data, safety and technology gaps. To do so, the report recommended a comprehensive approach that includes information-based strategies, direct regulation, extended producer responsibility, technical assistance, market-based incentives, and public support for research and education. These interventions can be applied in ways that affect either the supply of, or demand for, green chemistry.

I. D. Options for Government: Creating Supply and Demand for Green Chemistry

In identifying options to promote green chemistry in California, the Science Advisory Panel developed a framework for analysis that:

1. Relates demand-side and supply-side interventions ("options") for carrying out core policy functions so as to address data gaps, safety gaps and technology gaps (**Gaps, Functions and Interventions**), and

2. Addresses **Key Behavioral Factors and Interventions** affecting changes in the government, private sector, and society/citizenry that could bring about the needed transformation of chemicals production and use.

As a first approach, the framework acknowledged that a range of government actions affecting both supply- and demand-side activities can and needs to be taken to promote green chemistry and sound chemicals policies:

- "supply" side options – initiatives in education, research, economic incentives, etc. that will help to facilitate the creation and dissemination of greener chemicals, processes and technologies, and

- "demand" side options – chemicals policy elements that will drive demand for these greener chemicals, processes and technologies, by better informing the market, providing a level playing field on which greener options can fairly compete, and creating a regulatory climate that drives both the development and the adoption of greener alternatives.

Matrix 1 (below) represents this approach as a means of arraying the various supply- and demand-side options developed by the Science Advisory Panel for consideration by the state, and illustrating their complementarities and interdependency. The matrix itself seeks to integrate into a single framework the supply-demand concept and three other approaches that have been discussed by the Panel:

1) the data/safety/technology gaps analysis described in the University of California's green chemistry reports;[13]

2) the "core functions of a chemicals policy" identified in a recent analysis by Environmental Defense Fund of U.S., European Union and Canadian chemicals policies;[14] and

3) the subsections of sections II and III of this report used to group the options generated by the Science Advisory Panel.

The primary utility of the matrix is as a means to evaluate how the available options:

- address the various gaps, policy functions and types of interventions;
- relate to each other, i.e., are complementary or interdependent; and
- are best combined to advance a balanced portfolio of measures to promote green chemistry, including both supply and demand stimulants, regulatory and non-regulatory initiatives, etc.

Any individual option will not necessarily be confined to a single matrix cell. For example, creating a state office of technical assistance would potentially apply to many cells on the supply side. Any given row or column in the matrix would likely have multiple cells filled in, although some cells may be left blank where not relevant, such as the intersection between "control chemicals of concern" and "provide funding for green chemistry").

13 *Green Chemistry: Cornerstone to a Sustainable California* (2008) and *Green Chemistry in California: A Framework for Leadership in Chemicals Policy and Innovation* (2006), University of California, Center for Occupational and Environmental Health, at http://coeh.berkeley.edu/greenchemistry/briefing/default.htm.

14 Denison, R.A. (2007) *Not That Innocent: A Comparative Analysis of Canadian, European Union and United States Policies on Industrial Chemicals* (Environmental Defense Fund, Washington, DC), at www.edf.org/chempolicyreport.

MATRIX 1: GAPS, FUNCTIONS AND INTERVENTIONS

<table>
<tr><td></td><td></td><td colspan="7"><——Supply-side——>
<——Demand-side——> (Demand-side spans from "Evaluate products, problems and solutions" to "Use incentives to boost demand for Green Chemistry")</td></tr>
<tr><td>Associated Gap:</td><td>Types of options / Core policy functions</td><td>Educate and do outreach</td><td>Conduct and support Green Chemistry R&D</td><td>Pursue voluntary and other supply-side initiatives</td><td>Evaluate products, problems and solutions</td><td>Develop policies and practices to prioritize chemicals</td><td>Utilize regulation to collect and act on information</td><td>Use incentives to boost demand for Green Chemistry</td></tr>
<tr><td rowspan="4">Data Gap</td><td>Identify/ prioritize chemicals of concern</td><td rowspan="8">Section II.A.</td><td rowspan="8">Section II.B.</td><td rowspan="8">Section II.C.</td><td rowspan="8">Section II.D.</td><td rowspan="8">Section III.A.</td><td rowspan="8">Section III.B.</td><td rowspan="8">Section III.C.</td></tr>
<tr><td>Track chemical production and use</td></tr>
<tr><td>Collect and develop data</td></tr>
<tr><td>Share/protect information</td></tr>
<tr><td rowspan="2">Safety Gap</td><td>Assess chemical hazards/ exposures/ risks</td></tr>
<tr><td>Control chemicals of concern</td></tr>
<tr><td rowspan="2">Technology Gap</td><td>Assess alternatives/ options</td></tr>
<tr><td>Innovate toward safer chemicals</td></tr>
</table>

Matrix 2: Key Behavioral Factors and Interventions (Approach 2)

Determinants of Change -- Leverage points to encourage the needed (governmental, private-sector, and societal) changes through green chemistry and engineering

KEY CHANGE FACTOR	INTERVENTION TYPE	SPECIFIC ACTIVTIES
Willingness		
-towards changes in production (flexibility)	address static mind-sets/encourage risk-taking	
-influenced by an understanding of the problem (i.e., what aspects of the technology need to be changed)	information dissemination/educational initiatives	
-influenced by knowledge of options or solutions (diffusion)	information dissemination/educational initiatives/databases	
-influenced by the ability to evaluate alternatives	methodology development and capacity-building	
Opportunity/Motivation		
-gaps in technological/scientific capability (compared to others in existing markets)	databases and demonstration/showcase projects	
-possibility of economic cost savings in existing markets or new/expanded market potential	perform and disseminate cost-benefit and market analysis	
-regulatory requirements necessitating technological changes	regulatory initiatives	
-consumer/worker/societal demand (making new markets)	require reporting to government/public enhance marketing/demand for greener technology	
Capacity		
- influenced by an understanding of the problem (i.e., what aspects of the technology need to be changed)	information dissemination/educational initiatives	
- influenced by knowledge of options or solutions (diffusion)	information dissemination/educational/initiatives/databases	
- influenced by the ability to evaluate alternatives	methodology development/technical assistance/capacity-building	
- resident/available skills and capabilities (for innovation)	capacity-building, education/training	
- outside assistance	state offices of technical assistance/university-based projects	

A second approach is represented by Matrix 2 (above), which explores the behavioral changes among the key stakeholders that rely on individual and organizational learning, adaptation, and innovation to effectuate supply-and demand-side transformations. Key actors must have the *willingness, opportunity/motivation, and capacity or capability* to adapt or innovate. These three affect each other, of course, and each is determined by more fundamental factors such as the social and industrial networks the firm is embedded in and the incentives that are created by government. Specifically,

> *Willingness* is determined by [1] attitudes towards changes in production in general, [2] an understanding of the problem (i.e., what aspects of current technology need to be changed), [3] knowledge of possible options and solutions, and [4] the ability to evaluate alternatives. Improving [3] involves aspects of capacity building through the diffusion of information, through trade associations, government-sponsored education programs, inter-firm contacts, and the like. Changing attitudes towards changes in production [1] often depends on attitudes of managers and on the larger culture and structure of the organization, which may either stifle or encourage innovation and risk taking. Factors [2] and [4] depend on internal intellectual capacities.
>
> *Opportunity and motivation* involve both supply-side and demand-side factors. On the supply side, technological gaps can exist between the technology currently used in a particular firm and the already-available technology that could be adopted or adapted (known as diffusion or incremental innovation, respectively), or alternatively the technology that could be developed (i.e., innovation). Consciousness of these gaps could prompt firms to change their technology, as could the opportunity for cost savings. Regulatory requirements could also define the changes that would be necessary to remain in the market. On the demand side, three factors could induce firms or technology suppliers towards technological change - whether diffusion, incremental innovation, or major innovation. These are [1] opportunities for cost savings or expansion of sales, [2] regulatory requirements, and [3] consumer/worker/societal demand for more environmentally-sound, eco-efficient, and safer industry.
>
> Capability or capacity can be enhanced by [1] an understanding of the problem, [2] knowledge of possible options and solutions, [3] the ability to evaluate alternatives, [4] resident/available skills and capabilities to innovate, and [5] access to, and interaction with, outsiders. Knowledge enhancement/learning [2] could be facilitated through deliberate or serendipitous transfer of knowledge from suppliers, customers, trade associations, unions, workers, and other firms, as well from the available literature. The skill base of the firm [4] could be enhanced through educating and training operators, workers, and managers, on both a formal and informal basis, and by deliberate creation of networks and strategic alliances not necessarily confined to a geographical area, nation, or technological regime. Interaction with outsiders [5] could stimulate more radical and disrupting changes. (Ashford and Hall 2009)[15]

The approaches described in the two matrices are complementary, but not identical. The first approach is sharply focused on identifying options for closing the data, safety, and technology gaps (discussed above) through a variety of initiatives related to carrying out core functions of a chemicals policy, while the second approach focuses explicitly on changing the *behavior* of all

[15] N. A. Ashford and R. P. Hall, Technology, Globalization and Sustainability: Co-optimizing Competitiveness, Employment, and Environmental through Technological Change and Trade, forthcoming MIT Press, 2009.

relevant key actors to bring about transformations. The next two sections of the report discuss specific options in depth. In Section IV of this report, we return to a summary of those options in the context of their affecting supply- and demand-side behavior.

II. Green Chemistry Options for California—the Supply Side

II. A. Green Chemistry and Engineering Education – The Needed Tools

Investing in green chemistry for the future in California requires special attention to the state's educational services. Teaching green chemistry concepts in primary and secondary schools could attract students to science by positioning chemistry as a tool to meet environmental and health challenges. Reformulating college curricula and offering fellowships and internships would prepare new scientists to be innovative in a critical field. Thus, as California businesses adopt green chemistry practices and strive for new green product development, the state will have prepared its workforce in advance to meet these needs.

Option 1: Train K-12 Science Educators

Develop a program to train K-12 science education teachers in the concepts of Green Chemistry

One of the key challenges to introducing green chemistry to the K-12 curriculum is that students are not introduced to chemistry until grade 10. Science, as taught in grades K through 9, is heavy on biology (including botany, zoology), geology (with meteorology), and ecology. Most students receive only the barest exposure to chemistry prior to their first formal chemistry course (typically sophomore or junior year in high school). Introductory chemistry concepts that appear before the first formal course take the form of simple descriptions of atoms and molecules with perhaps some physical chemistry fundamentals (states of matter, phase changes, etc). Further, the first (and often only) chemistry course typically includes a very limited amount of organic chemistry.

The large numbers of chemistry lesson plans and sample experiments that are designed for students in the K-8 grades are not reaching a significant fraction of the target audience. This is often due to the lack of training of K-8 teachers in these subjects, and a lack of appreciation of the great extent to which chemistry has permeated our economy and our lives. As such, one way in which green chemistry can be promoted at the K-12 level is to train K-12 teachers in the important concepts and create (or use off-the-shelf) relevant experiments to illustrate the concepts. Such training programs could be provided through a variety of mechanisms, including:

- in-service professional training programs offered through various professional associations,

- continuing education programs offered by college teacher training programs, and
- summer enrichment training programs tied to certification and accreditation requirements.

An alternative view is that the priority in K-12 education should be to ensure student proficiency in reading, mathematics, social studies and the basic concepts and tools of science. Even under this view, some creative teaching materials on green chemistry may be an exciting way to help generate student enthusiasm for the concepts and tools of science. In this way, teaching green chemistry can be viewed as an innovative tool for teaching science.

Option 2: Develop K-12 Green Chemistry Teaching Materials

Expand California's science education materials programs to include training and laboratory materials for conveying concepts in green chemistry to K-12 classrooms suited to each grade level.

Regarding the teaching of green chemistry to K-12 students, there are some broad analogies that can be drawn to illustrate the basics. Clearly, chemistry can be rendered palatable to younger students in an informal sense via analogies to cooking, where the latter's various ingredients and techniques compare nicely to the conduct of chemical reactions. One of chemistry's most powerful applications is simply "making things around us," and hence relating chemistry to the creation of materials is a useful teaching tool.

In both cooking and materials synthesis, concepts of waste minimization are easy to illustrate. Concepts surrounding toxicity/hazard will be more difficult to convey, given that the conventional wisdom among children is likely that all chemicals are hazardous. Conveying concepts in green chemistry to K-12 (and more importantly, K-8) will therefore require relevant teaching materials suited to each grade level. This dovetails with the need for teacher training noted above. By developing a wide array of teaching and laboratory materials, the state of California could render the teaching of green chemistry principles more tractable. Because supply budgets at the K-12 level are so tight, California could provide the supplies needed to conduct green chemistry experiments to those teachers who complete the green chemistry science educators training program noted above.

Option 3: Develop Green Chemistry Interdisciplinary Education Courses

Develop programs to introduce interdisciplinary green chemistry into the general education curriculum for undergraduates in California colleges and universities.

Too often, non-chemistry majors avoid general chemistry courses because they are too abstract and quantitative. Introducing green chemistry into such courses creates new opportunities to demonstrate the social relevance and positive benefits of chemistry**.** The concepts of green chemistry can be taught through sets of interdisciplinary courses thereby making them available to a wider range of students, many of whom may not be chemistry or chemical engineering majors. Knowledge is necessarily less specific and is broadly defined often in terms of choices, assessments and impacts. The purpose here is to make a wider range of students aware of the issues and thereby cause the topic itself to be mainstreamed.

In the last thirty years, there has been a proliferation of interdisciplinary undergraduate majors that cover environmental protection. They may be called environmental science, environmental policy, environmental studies, sustainability or other closely-related terms. It is critical that the science of green chemistry be integrated into the curricula of these interdisciplinary majors.

John Warner designed a model course called “Environmental Concerns and Chemical Solutions” that was presented as a “Gen Ed” environmental science elective for undergraduates at the University of Massachusetts Boston. Each section of the course was organized around three parts: 1) the description of an environmental issue (e.g. global warming, ozone depletion, water pollution, persistence, etc.) including the historical, political and social implications; 2) the chemical science behind the issue (e.g., thermodynamics, kinetics, acid/base, redox, etc.); and 3) the industrial processes linked to the issue and the green chemistry solutions that could be developed or were being used in practical applications.

Such green chemistry classes could be offered in diverse academic centers ranging from community colleges to the University system at levels that would make them open to students across various science disciplinary bounds. These courses would essentially serve to develop a more educated and illuminated student population, some of whom would take specialized courses covering green chemistry concepts in their specific disciplinary focus areas. The courses would thus be distinct or loosely aligned and would essentially serve as electives.

Option 4: Integrate Green Chemistry into Higher Education Chemistry and Chemical Engineering Curricula

Reformulate conventional graduate and undergraduate chemistry and chemical engineering curricula in California colleges and universities to emphasize green chemistry and to include aspects of toxicology, health related issues, ecology, environmental science and environmental law.

The concept of specialization is exemplified by the development of the world's first doctoral program in Green Chemistry at the University of Massachusetts. The establishment of this program enabled students to specialize in this new discipline. A number of other universities integrated green chemistry into existing advanced degree programs through specialized courses. Both approaches place tremendous emphasis on the treatment of aspects such as toxicity and downstream environmental impact as among the principle characteristics of a material, making these aspects to be routinely considered in the design of materials and processes.

Reformulating traditional chemistry and chemical engineering curricula in this way would emphasize green chemistry and include aspects of toxicology, health-related issues, risk assessment, ecology, environmental science and environmental law. Models of such courses have been developed and described in reports such as *Real World Cases in Green Chemistry* from the University of Scranton and *Going Green: Integrating Green Chemistry into the Curriculum* by the American Chemical Society.

Such an expansion of curricula could be accomplished in very much the same way as waste reduction and pollution prevention were introduced in the early to mid-90s. Typical scenarios and problems used in courses are intrinsically changed to reflect choices and selections involving green chemistry and its implications. Students graduating from such programs would thus not only be qualified to enter professions with the requisite training as chemists or chemical engineers but would also have specific and specialized knowledge regarding assessments and improvements related to green materials, processes and products.

An example of the restructuring of a conventional laboratory course to emphasize green chemistry principles is seen in the undergraduate course on organic chemistry taught by Prof. James Hutchison at the University of Oregon and described in K. Doxsee and J. Hutchison, *Green Organic Chemistry: Strategies, Tools, and Laboratory Experiments*. An obvious area of discussion under this curricular construct is whether students would first need to master basic concepts in chemistry/chemical engineering before being exposed to the specific attributes of green chemistry/engineering, or whether the restructuring could itself take place at the very basic levels, thereby truly integrating these topics into the formal curriculum from the outset.

California essentially needs a combination of both models, with the latter serving to educate and inform its citizens, and the former serving to specifically develop a subset as topical experts in this area.

Option 5: Develop Fellowships and Internships in Green Chemistry

Develop a program to support graduate education fellowships and both undergraduate and graduate internships focused on green chemistry research and application.

One of the most important areas of training for chemists, engineers, molecular scientists, and those wishing to be scientifically informed citizens is the practical, hands-on laboratory experience. Research training is an essential element for practitioners of science and engineering and it is a great opportunity to expose students to the tools, techniques, methodologies, and principles of green chemistry. Currently, there are few mechanisms that support the opportunities for students to explore this important area of research in green chemistry. In order to advance green chemistry through education and research**,** the State of California could develop a program to support fellowships and internships focused on green chemistry research. Such a program would benefit from partnership with other interested parties including the federal government and national laboratories, industrial interests including individual companies and industrial sectors, and non-governmental organizations including philanthropic institutions. The program could include the following elements:

- Universities in California seeking to develop internship partnerships with industry to provide practical experience in green chemistry could apply for seed grants to launch the program.

- Twenty-five graduate student research fellowships in green chemistry would be offered competitively to students doing research on any area of green chemistry at the Ph.D. or Masters level. Funding would cover stipend and tuition.

- Twenty-five undergraduate research fellowships in green chemistry would be offered competitively to students doing research on any area of green chemistry.

- Ten post-doctoral research fellowships in green chemistry would be provided to outstanding candidates and would supply matching funds to the principal investigator at a university or national/state laboratory in California to cover the salary of the researcher.

- Five grants for two years would be awarded annually on a competitive basis for universities, four-year colleges, and community colleges in California to develop laboratory training modules undergraduates to have exposure to green chemistry in the teaching laboratory.

Option 6: Promote Green Chemistry in Business School Education

Commission the development of practical teaching cases in green chemistry that can be incorporated into the curricula of business schools through the university systems in California.

The future of green chemistry requires an informed and knowledgeable business community as well as trained technical and scientific staff. Awareness of green chemistry solutions can be aided by integration of the concept into the education of future business leaders. As green chemistry offers considerable business opportunities as well as some commercial risks, the training of future business leaders should include an introduction to green chemistry. The state of California could take a pioneering step by commissioning the development of practical teaching cases in green chemistry that can be incorporated into the curricula of business schools through the university systems in California. Such cases could cover subjects ranging from production management and investment decisions to product design and product marketing. If these cases are successful, they can serve as a model for innovation in business education elsewhere in the United States and around the world.

Option 7: Support new Faculty Positions in Green Chemistry

Encourage and financially support the hiring of faculty qualified in green chemistry throughout the state's colleges and universities.

The training of college students in the various subjects necessary to develop well rounded capacity in green chemistry will require qualified faculty capable of teaching such subjects and organizing effective green chemistry research programs. Not only is there a need for faculty prepared to teach and conduct research in green chemistry, but there is a need for academic positions for those who are graduating from the state's higher education institutions where green chemistry is being taught.

The state of California can assure that there is sufficient teaching and research capacity by providing funding specifically directed towards new positions in green chemistry within the conventional disciplines of chemistry and chemical engineering. In addition, the state could encourage and support the hiring of other faculty capable of teaching the non-chemistry requirements in toxicology

and health, risk assessment, environmental science and environmental law and policy.

This hiring program could be launched as a competitively-based program where various state colleges submit applications for three- to five-year faculty support grants that support new positions and new hires. While such specially targeted hiring programs may be needed in the early years of introducing green chemistry into the state colleges, this program might not be needed once green chemistry has been firmly established and the concepts and principles are taught routinely throughout the various curricula. Therefore, this specially targeted hiring program might best be established as a seed funding program that lasts no longer than a necessary period.

Option 8: Introduce Green Chemistry into Vocational and Workforce Development Training Programs

Support and fund a green chemistry program for vocational schools and other workforce development programs.

As California firms move to adopt and integrate green chemistry applications into existing production or open up new ventures based around green chemistry products and solutions, there will be a growing need for workers trained in new areas of production and product design. Indeed, a serious commitment to green chemistry has the potential to create new green jobs that help lower-skilled and lower-income workers get into the workforce and move into meaningful careers.

To assist these opportunities to emerge and flourish, it is important that the state provide encouragement and support for vocational training and workforce development programs that integrate green chemistry concepts and principles into established skill development training programs. The state could set aside specific funding and target such funds to local, municipal and community-based programs that offer new training opportunities that prepare students for green chemistry and green product services.

Community-based organizations and non-profit economic development programs that offer services to lower skilled and disadvantaged workers should be made aware of opportunities emerging in firms adopting green chemistry technologies and practices. Such services can provide access for those seeking employment in new green jobs to get the training that will prepare them to handle new technologies and perform new services.

II. B. Research, Invention, and Innovation in the Context of Green Chemistry and Engineering

Science and technology is at the heart of green chemistry. It is what allows green chemistry to design, discover, and implement the new products and processes that perform better and are safer for human health and the environment. With a strong science and technology component, California's Green Chemistry Initiative process can be a leader in demonstrating the ability to design truly sustainable products, processes, and industry sectors. In the absence of robust support for this essential pillar of green chemistry, the benefits will be a pale reflection of the power and the potential of green chemistry to be an engine for California in building a strong, healthy economy and community.

Current Status:

- Currently, California has, in place, the building blocks for excellence and leadership in green chemistry. There is a significant amount of expertise that resides in both the public and private universities of the state, as well as in other research institutions. This expertise, however, is largely uncoordinated, unrecognized, and underutilized as a source of innovation in moving California forward in the area of green chemistry.

- There is a fundamental lack of support for research efforts at all levels. Current green chemistry efforts are largely the result of "bootstrap" efforts of academic entrepreneurs.

- There are examples of green chemistry awareness and notable accomplishment in industrial interests in California. However, there is tremendous untapped upside potential for the systematic adoption of green chemistry principles in the development of new products, processes, and markets.

- Partnerships and collaborations will be an essential piece of the successful implementation of the California Green Chemistry Initiative, and the science and technology component is an area where there is tremendous potential for partnerships including industry/university, state/federal, and NGO/academic collaborations.

- Visibility and recognition of scientific and technological achievements in both industry and academia is needed to both allow for maximum benefit from the accomplishments and to provide model case studies for people to be emulated and built upon.

- Significant research and development tools are needed in order to allow green chemistry to grow and develop in California for maximum benefit. These tools can range from scientific equipment and instrumentation to new computational capabilities to access to demonstration and testing facilities.

The field of green chemistry is a well-established area of science that has been well-defined in the scientific literature for over fifteen years. The definition, scope, and principles are documented and have received years of rigorous peer-review from the scientific community. There are several scientific journals devoted to the topic, scores of conferences and symposia, national initiatives in dozens of countries in green chemistry, and legislation and other governmental policies that incorporate green chemistry.

It is essential that the integrity of this framework is preserved by the state of California and that it remains in alignment with the well-established foundation in the face of pressures that are natural with the establishment of a governmental initiative. There is a normal inclination to expand, adjust, redefine, or otherwise modify programs to fit constituencies or interests. While often well-intentioned, these efforts would have detrimental unintended consequences of dilution, distraction, and derailing the important goals of innovation for environmental, human, and economic benefit.

In order to ensure the integrity of the Green Chemistry Initiative, the following steps are suggested as overarching principles:

1. Formally adopt the definition of green chemistry as “the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances.” Further, the twelve principles of green chemistry, as they enable development and utilization of practically applicable materials, should be adopted as the guiding framework for the California Green Chemistry Initiative.

2. Establish a California Green Chemistry Science and Technology Council that has the participation of national and international leaders in the green chemistry community, in addition to the expertise in the state. This Council would be tasked with review and oversight of the science and technology programs of the California Green Chemistry Initiative, as well as those other elements of the Initiative that have an important scientific component.

Option 9: Implement a process to identify all on-going efforts in Green Chemistry Science and Technology in California, and use that to determine critical gaps in Green Chemistry Research and Technology

To build an effective green chemistry program, it is essential to identify the ongoing efforts in green chemistry science and technology currently taking place in California. The following actions would provide an understanding of current activities in California of green chemistry science and technology.

1. Identify an independent third-party group, external to California, to conduct a 9-month audit of green chemistry activities in California that would:

    a. Identify all research programs in green chemistry at public and private universities and colleges of California (in all departments, schools, and centers).

    b. Identify green chemistry research and development in industry that has led to commercialization of improved products.

    c. Identify all science- and technology-related programs in the state government and the federal government operations in the state of California (e.g., national laboratories)

    d. Identify any non-governmental, not-for-profit, philanthropic organizations, advocacy or research institutions with programs to advance green chemistry science and technology.

2. Compile any gathered data in a searchable database of maximum use in identifying opportunities and needs.

3. Conduct a gap analysis that reviews the current portfolio of green chemistry science and technology in California and provides an analysis of where the state has strengths weaknesses, opportunities, and needs. This study should be augmented by a review of overall green chemistry research needs (including a review of previous key reports on green chemistry research challenges by the National Academy of Sciences, the U.K. Crystal Faraday Partnership) to identify those areas of most important research investment for California. This report should be provided to the Green Chemistry Leadership Council no later then one year following the adoption of a green chemistry process.

Option 10: Support Green Chemistry Research and Development Efforts in California

To advance genuine green chemistry in California, it is essential to have strong, sustained and robust support for the green chemistry research and development efforts in the state. The following actions, if taken by the state of California, would further this goal:

1. Establish a $10 million Green Chemistry Research Fund to provide a minimum of forty, $250,000 direct grants annually to faculty at universities and colleges in California. The fund would be overseen by the Green Chemistry Council and should be focused on those areas identified as

being crucial to development of Green Chemistry Science and Technology through efforts undertaken following the audit discussed above.

2. Establish a policy at all California state institutions of higher learning that any research grants that are deemed to be supporting green chemistry science and technology will receive specific institutional support.

3. Establish supportive tax credit and other policies to encourage and reward corporate support of research and development activities at California Universities and Colleges in the area of green chemistry.

4. Establish a patent assistance program that will provide funding for academics, small businesses, and entrepreneurs to cover the costs of patenting innovation in green chemistry science and technology.

5. Establish an overall policy for intellectual property ownership for projects funded by the state of California and by public-private partnerships to ensure that the public receives the benefits of resources allocated to this enterprise, while maintaining a commercial incentive for private partners to collaborate with public actors.

Option 11: Promote, Encourage, and Facilitate the Development of Industry – University Partnerships

A key component of any plan for the state of California to establish a leadership position in green chemistry and engineering must include state university-based programs that encourage collaboration with the private sector. Academic institutions in California are extremely strong already in all aspects of green chemistry and engineering: chemistry, chemical engineering, business, public policy, natural resources, etc. However, the resources of the universities are not linked together in a way that builds leverage across all the terrific resources in the system. As this university-based program is established, it will be critical to gain business partners to help build the necessary linkage to companies who can provide real-life inputs on the needs for new products and to advise concerning the commercialization of new products. Any green chemistry and engineering innovation must naturally grow into a successful commercial product for it to make a difference in the world. This partnership with the private sector is very important for that reason, in addition to assisting with the identification of challenges and opportunities for research.

Lastly, the state of California should consider setting up a university system-wide policy for intellectual property ownership for projects funded by the private sector with the proposed state university consortium. A common, fair intellectual property agreement would facilitate and hasten private sector research collaborations. The current myriad of school-by-school negotiations is a barrier to

many established and emerging venture capital companies in working with the university system. Lowering this barrier to collaboration would help speed California to the forefront of research and commercialization of green chemistry and engineering solutions and products. In order to accomplish this, the state of California should consider the following actions:

1. Establish Green Chemistry Institutes within the University of California system that would enable focused research and development using strong public-private collaboration. The Institutes should be structured following the highly-successful California Institutes for Science and Innovation program implemented earlier by the state.

2. Establish an infrastructure within these institutes and other specially-established centers to not only focus on education and research, but also to aid implementation by providing the means for testing new products and solutions in a real-world context. The focus should be on accelerating innovation and product introduction, ultimately strengthening California's economy.

3. Establish a common, fair, intellectual property agreement that facilitates private-sector investment in research and university collaborations and ensures a public benefit from such collaborations. Agreements could be modeled on those established by the California Institute for Regenerative Medicine to promote public-private collaboration.

Option 12: Strengthen the Green Chemistry Infrastructure

The implementation of green chemistry will only be successful if an appropriate level of supporting infrastructure is established and supported. This includes aspects such as specially-established innovation centers that focus on the transformation of ideas into reality, support for entrepreneurs and small businesses, specially-designed test labs and sites for assessment of new chemical formulations and products, and a deliberate focus on further development of the science of toxicity testing. It is crucial that the state of California put in place mechanisms that not only support and further encourage innovation and implementation, but also enable rapid testing and assessment of products and the continued development of methods of systematic assessment. In order to accomplish this, it is recommended that the following actions be considered by the state of California:

1. Establish unique Green Chemistry Science and Technology Innovation Centers across the state, charged with enabling and encouraging the development of innovative technology and products as well as the support of entrepreneurs and small businesses. These centers would not only serve as incubators but would also provide other assistance and support

such as development of business plans, financing, teaming, legal and regulatory requirement support, etc.

2. Establish specialized laboratories and test sites operated by the state in conjunction with academic institutions to enable the rapid and timely testing and assessment of new chemical formulations, products and technologies. It is essential that these centers and test sites are, and are perceived to be, independent, and that all results are based on technical and scientific results.

3. Establish centers for the advancement of the science of toxicity testing.

II. C. Other Incentives to Boost Green Chemistry Supply

Other proposals not previously characterized fall into three categories: voluntary action by industry, incentives based on recognition, competition or targeted grant programs, and technical assistance programs.

Voluntary Action by Industry

This section includes two proposals that could be undertaken by forward-looking individual companies or trade associations.

Option 13: Implement management system approaches for California Chemical Manufacturers

A management system is a recognized business management practice that allows an organization to strategically address its environmental, health and safety matters for processes and products. Systematic implementation of quality management principles based on the “Plan, Do, Check, Act” model forces companies to identify goals, implement them, determine progress, and modify systems to ensure continual improvement. Properly implemented, a management system not only improves performance, but also increases overall efficiency and accountability[16, 17] Two examples of such systems include Responsible Care® and ISO14001.

[16] See original 2004 resolution on environmental management systems developed by the Environmental Council of the States (ECOS) at
http://www.ecos.org/files/1171_file_Copy_of_Resolution_97_4_REV_10_5_04.pdf
and updated resolution at
http://www.ecos.org/files/1171_file_CMC_EMS_Resolution_Number_97_4_FINAL.doc

[17] Implementation of Responsible Care® is a requirement for membership in the American Chemistry Council. ACC Responsible Care® Management System Certification
http://www.responsiblecaretoolkit.com/cert_intro.asp
IS0 14001 at http://en.wikipedia.org/wiki/ISO_14000
American Chemistry Responsible Care® performance metrics

Included in the idea of a modern management system is the principle of greater transparency in decision-making. Responsible companies conduct systematic and rigorous evaluations of their chemical products to assure that these products deliver their intended benefits, while protecting public health and the environment. These evaluations should include characterizations of risk associated with the use of the chemical products and a determination of any risk management precautions and activities needed to address that risk. California public stakeholders would benefit from a greater understanding of how product safety and management decisions are made. Stakeholders and California agencies would gain a greater understanding of those companies that have rigorous systems versus those that do not and may thus warrant greater scrutiny.

Chemical manufacturers and users in California would: (1) implement a management system that includes process and product safety elements; (2) arrange for third party certification by representatives of a nationally-recognized auditing board (e.g., Board of Environment, Health and Safety Auditor Certifications or ANSI-ASQ-National Accreditation Board); and (3) affirm to the state that the management systems are in place and that third party certification has occurred.

A company that manufactures chemicals in California would have a publicly-available overview of the approach it uses for chemical evaluation and assessment. Companies would affirm to the state that the chemical evaluation and assessment approach is publicly available. The state could maintain records of company statements/affirmations, and encourage non-participating companies to consider doing so.

Option 14: Promote Green Chemistry by Industry Associations

The chemical industry has a record of voluntary action that has allowed members to distinguish themselves in environmental performance. Ranging from programs in collaboration with U.S. EPA (such as “33/50”) to the American Chemistry Council’s Responsible Care® or the implementation of ISO14001, industry has taken action to address improved performance.

The state of California could challenge national and state associations to implement green chemistry in the spirit of continuous improvement and in consideration of the twelve principles. In return, the state might promote those companies showing exemplary results (see Option 37 “Green Chemistry Marketing, Option 18 “Governor’s GC Innovation Award” and Option 36 “State Procurement of Green Products”).

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http://www.americanchemistry.com/s_responsiblecare/sec_members.asp?CID=1320&DID=4863
At http://reporting.responsiblecare-us.com/reports/PrdctSfty_Cmpny_Rpt.aspx, one can access links to company’s reporting to ACC on chemical evaluation process. For example, Dow Chemical Company at http://www.dow.com/productsafety/assess/

Option 15: Promote Value Chain Communications

This option is designed to encourage companies in important value chain sectors to identify information needs of the value chain's members (upstream and downstream companies) and to establish communication processes to meet those information needs. By facilitating the flow of information regarding hazards, potential exposures and safe handling procedures along the value chain, California will enable companies within a value chain sector to access risk information and apply risk reduction measures for its own operations and for its own products. Reducing barriers in communication can help companies develop and market safer, more effective products.

The state could identify industry sectors of key importance and determine organizations/businesses within that sector's value chain (upstream & downstream parties). The state would work with parties in that value chain sector to survey needs and expectations of value chain members. Industry would be encouraged to collect key information, such as: (a) availability of technical expertise to apply risk information provided for its own operations and products within company/organization, (2) product stewardship programs/activities within company/organization, (3) information provided to downstream users; and (4) information received from upstream suppliers.

The state would then compile information provided in the surveys. From this, the state, the public and companies could determine what, if any, information needs are unmet and to determine if there are gaps on technical expertise in risk management within value chain.

This option would apply to chemical suppliers, distributors, processors and consumer product manufacturers.

Incentives Based on Recognition, Competition or Targeted Grant Programs

Incentives for innovations described in the following options could include recognition alone, or financial rewards. The state could, working with appropriate stakeholders, identify the types of incentives it believes to be the most beneficial for encouraging and nurturing green chemistry products and processes.

Thus, California could make financial capital available to applicable companies at preferential terms, whether via grants or lower interest loans, to encourage green chemistry and green chemistry and engineering manufacturing process development. It could also offer a tax incentive for companies to develop and/or promote green chemistry and green engineering products and processes.

Option 16: Awards programs and competitions: Establish Green Chemistry Innovation Awards, Governor's Green Chemistry Award, and/or Green Chemistry Business Plan Competition

The U.S. EPA established the Presidential Green Chemistry Challenge Awards[18] program in 1995. In the intervening twelve years, professors, students and companies large and small have been awarded prizes for outstanding achievement in the use of greener synthetic pathways, the use of greener reaction conditions, and the design of greener chemicals. The success of the program is perhaps best measured by the increasing number of applicants each year, and the recognition of companies all along the supply chain, from basic materials to consumer products.

The state of California could consider establishing a similar recognition program, honoring innovation in national companies making a significant impact on consumer products in California, small companies based in California and California universities.

The awards would be presented every year at a California Green Chemistry Forum that would highlight technical and scientific achievements in California. Leading practitioners in California would be invited to present their work. This forum should be open to the public, business, investors, and philanthropic foundations.

A significant advance in awards programs that could be catalyzed by the state is a competition for the best business plan based on commercialization of green chemistry. This competition would depend on the three legs of green chemistry: efficacious, cost-effective products with reduced environmental impact. The state could partner with California venture capitalists to award an investment-based prize for commercialization of the best business plan. As with other competitions, there would be public recognition of attractive plans that did not win the prize but finished well in the competition. These plans might have a better chance of attracting funding as a result.

Option 17: Establish a "California Chemistry Research Challenge"

The state could address potential gaps in "green" alternatives by creating a challenge program targeted at a "top ten" list of materials and/or uses, then soliciting proposals for alternative design. Top ideas would be funded by the state, with the aim of including both technological success and commercialization.

[18] http://www.epa.gov/greenchemistry/pubs/pgcc/presgcc.html

The program would function much like a green, state-sponsored version of the business model used by companies like InnoCentive,[19] NineSigma,[20] or the Green Chemistry Institute's Pharmaceutical Roundtable innovation awards[21] In each of these programs, problems are identified and solutions are solicited from researchers. Grants are awarded for solutions deemed the most promising.

Technical Assistance Programs

A supply-side approach to advancing Green Chemistry not only requires appropriate incentives and capacities, it may also often require special technical services that can assist California businesses in the transition to less-hazardous processes and products. Such technical assistance may come in the form of tailored information services, workshops and professional conferences or more conventional on-site professional services.

Option 18: Develop a "Green Chemistry Web Portal"

The green chemistry community has grown significantly over the years, and journals, newsletters and communities of practice exist. However, there is not a definitive portal that serves to organize and connect this community with the variety of resources that could further the implementation of green chemistry into education, public policy and private sector practice. The state of California could undertake the development of a portal, largely electronic, which would enhance, accelerate and drive the implementation of green chemistry in the state and elsewhere.

Six main areas are proposed, but the concept could easily be utilized for other topics or grouped in different ways. These have been suggested because they are identified as areas which will increase the use of green chemistry. Several common threads pertain to all of the topic areas.

- The portal would compile and disseminate materials and case studies to educate and further best practices. Examples of policies which have furthered green chemistry and those which have suffered from unintended consequences would be helpful to advocates and elected officials.

- The portal would establish a community where topics can be debated, questions can be posed and interested parties can contribute as well as

[19] http://www.innocentive.com/

[20] http://www.ninesigma.com/

[21] http://portal.acs.org/portal/acs/corg/content?_nfpb=true&_pageLabel=PP_TRANSITIONMAIN&node_id=1422&use_sec=false&sec_url_var=region1

further their own knowledge using a variety of tools such as message boards, blogs, webinars, workshops, etc. For example, there is not consensus on the relevant social metrics to be considered in life cycle analysis and how they might be measured.

- The portal would compile syllabuses, textbooks (including the opportunity for online ratings to be posted), case studies, publications and other tools for educators promoting and incorporating green chemistry into their classrooms and labs. Many universities have developed portals targeting educators, but they have not been integrated into broader aspects of green chemistry, such as life cycle, private sector tools and public policy.

- Another feature of the portal could be the identification of grant programs and funding opportunities for green chemistry research, projects and program development.

- Along these lines, the portal could also highlight conferences and awards which focus on green chemistry and promote them within the community of practice.

- Because there are many commercial opportunities in this field the portal could be funded, partially or completely, by revenues from practitioners who wish to advertise their products and services.

Option 19: Add Green Chemistry to State Technical Assistance Programs

California has a long history of providing small business technical and financial services. The state economic development agencies provide training and on-site assistance to small businesses on subjects ranging from marketing to business planning. Since the 1980s the state has maintained a waste reduction and pollution prevention service to assist small- and medium-sized firms in reducing waste and pollution. In addition, there is an active state program providing on-site services to conserve energy and reduce greenhouse gases. The state of California could expand these state technical assistance services to include assistance in the adoption of green chemistry solutions. Indeed, some of the current waste and pollution reduction assistance may already include some green chemistry solutions.

In all of these cases, the expansion of services to cover green chemistry solutions will require more than mere platitudes. A well-directed program to advance green chemistry among small- and medium-sized firms will need to focus on capacity-building with specific initiatives including:

- Organizational managers must be informed and the current portfolio of services must be adjusted or rewritten to include information and training resources that describe green chemistry and demonstrate its usefulness.

- Important to such efforts will be the direct training of the current technical assistance providers. Staff training and opportunities for staff to visit sites and see first-hand demonstrations of green chemistry will be important.

- Lastly, encouragement for promoting green chemistry in these technical services will be increased if small amounts of funding are made available to service providers to redraft curricula, attend courses, purchase textbooks and other curriculum resources and upgrade current facilities and equipment.

II. D. Evaluating Products, Problems and Potential New Solutions

There is a need for both (1) the development of methodologies for evaluating existing or new chemicals/products, processes, and approaches, and (2) strategies for developing new green technological and organizational solutions and approaches. Addressing these needs requires options to build both the capacity or capability of individual researchers and the establishment of institutional arrangements to fulfill these needs. Options 20 and 21 are relevant to these tasks[22]

Option 20: Advance the Science of Alternatives Assessment

In the context of evaluation, the art and science of alternatives assessment needs to be advanced in order to provide clarity and consensus about what is indeed a greener alternative. Alternatives assessments should consider the full life cycle of a chemical, material or product including the associated chemical hazards, energy quantity and quality, and sustainable material flows. Processes for engaging stakeholders in alternatives assessments are also needed to scope out desirable and feasible options and to reveal the many dimensions of a green chemical/material/product, process, or approach[23]Alternatives assessments may be narrow, comparing hazards associated with chemicals for the same functional use or they may be broad, comparing chemical technologies to non-chemical and

[22] Options 12, 13, and 18 discussed in the regulatory options cluster in Section III are also relevant.

[23] As tools for assessment are developed, they must incorporate the best possible data on both existing alternatives and the anticipated nature of innovative technologies and approaches. The reader is referred to the discussion of Data Needs and Availability found in Appendix A, addressing what is available, what will be available, how currently unavailable information might be made public or generated while minimizing duplication and wasted effort, and what new information is needed related to innovative technologies and approaches. See also discussion in this section (II.C.) and section III.C. of this report for a discussion of the creation of incentives to generate and disseminate needed information.

entirely different processes or approaches. (Appendix D contains examples of various alternatives assessment approaches, including evaluations of the range of scope and applicability and a list of characteristics that can be used to describe and differentiate among the approaches.

Advancing the science of alternatives assessment may be accomplished by:

- establishing one or more independent non-profit alternatives institutes that advance the science of alternatives assessment, in addition to developing and evaluating alternatives;

- including alternatives assessment as a key focus area in green chemistry education;

- providing funding for research and fellowships that focus on alternatives assessment at California universities; and

- allocating resources for further developing and gathering and disseminating alternative assessment frameworks and tools.

By advancing the science of alternatives assessment, California will be better positioned to provide needed guidance to industry and others who seek to provide greener chemicals/materials/products, processes or approaches.

Option 21: Establish one or more independent non-profit institutes to identify, develop, and test safer alternatives

Chemicals are widely used in industry and most user industries (including chemical users, suppliers and trade organizations) do not have the expertise or sufficient motivation to find, test, develop and optimize safer alternatives. An ‘alternatives institute’ could work with different industries/applications to identify and demonstrate safer alternatives focusing on a number of areas of widespread interest, such as solvents, metals, coatings, etc., or to develop these alternatives where they do not exist. In appropriate cases, regulations could be promulgated by DTSC or other state or local agencies to require the adoption of these alternatives.

Various air, wastewater, hazardous waste and worker exposure agencies would work with the institute to identify applications of high priority. The institute staff would include experts in problem sectors who would work with user industries, companies and consumers to test and optimize use of alternatives.

III. Green Chemistry – The Demand Side

Driving demand for green chemistry requires that public policies allow both state agencies and the chemicals market to clearly distinguish safer and environmentally preferable chemicals (and associated processes and technologies) from those that pose concerns for human and environmental health. As defined in this report, "demand" side options encompass chemicals policy elements that will drive demand for these greener chemicals, processes and technologies, by better informing the market, providing a level playing field on which greener alternatives can fairly compete, and creating a regulatory climate that encourages both the adoption and the development of green chemicals/products, processes, and approaches.

Taken together, demand-side options aim to:

- develop and disseminate sufficient information about chemicals (their hazards, uses, exposures, etc.) to facilitate their efficient and accurate assessment;

- send clear signals to policymakers and the market, by articulating and applying criteria to identify both chemicals of concern and those of low or no concern;

- influence and inform chemical design, production and selection decisions; and

- empower a range of actors – government, chemical producers and processors, business and institutional purchasers, users and sellers of chemicals and chemical products, workers, academics, consumers and the public – to advance knowledge and make informed decisions about chemicals.

III. A. Identifying and prioritizing chemicals of concern

This subsection describes three basic options intended to lay the foundation for a better-informed and more transparent public policy and chemicals marketplace that is able to identify and prioritize among chemicals of concern, as a means of facilitating their replacement with greener alternatives. The other subsections of this section describe additional means to drive demand for green chemistry, including regulatory measures and incentives.

Option 22: Adopt a policy to identify chemicals of concern, including, as appropriate, associated processes and approaches, and develop specific criteria for this purpose.

Articulation of an official policy by the state of California would establish a framework under which specific criteria that define the attributes of chemicals of particular concern to the state can be developed and communicated to the range of entities that make decisions about chemicals. Such a policy framework can then be used to direct and drive further needed efforts: development of information about chemicals produced and used in the state (focused on those attributes); efficient assessment and prioritization among chemicals sufficient to determine whether or to what extent they meet the criteria; and, as appropriate, initiation of actions to reduce production, use and release of chemicals of concern and to replace them with alternatives known to be of lesser or no concern.

While the policy itself would broadly describe the attributes of chemicals of concern, it could put in motion a process and timeline under which specific criteria are to be developed that can be used to determine these attributes. That process would be driven by government, but would also entail input by a range of stakeholders.

Attributes and their associated specific criteria can be hazard-based or exposure-based. Examples of chemicals displaying hazard-based attributes and criteria include PBTs (persistent, bioaccumulative and/or toxic chemicals) or chemicals known or suspected to be carcinogens or reproductive toxicants (the approach used under the state's Proposition 65). Examples of exposure-based attributes and criteria include chemicals detected through biomonitoring or environmental monitoring (e.g., of drinking water) or chemicals used in products with which children are likely to come into contact.

Criteria-driven policies have been developed by other countries as a core element in revising and updating their chemicals policies. For example, the 1999 amendments to the Canadian Environmental Protection Act (CEPA) mandated that Environment Canada and Health Canada categorize the roughly 23,000 chemicals on its Domestic Substances List (DSL). Categorization entailed identifying chemicals that possess the specific attributes specified in the statute: a) persistence, b) bioaccumulation potential, c) inherent toxicity to humans or nonhuman organisms, or d) of greatest potential for exposure to humans, based on available information[24] In applying these criteria, the government has used them both to identify all chemicals possessing one or more of these attributes, and to further prioritize among these.

[24] CEPA 1999, §73, available at www.ec.gc.ca/CEPARegistry/the_act/Contents.cfm.

The European Union's recently-adopted REACH Regulation is also attribute- and criteria-driven, using hazard-based criteria, surrogates for exposure, and other attributes to drive the registration, evaluation and authorization processes it establishes. Two sets of hazard criteria play pivotal roles in REACH. One is inherited from another EU regulation: classification of chemicals as "dangerous" using criteria for sixteen hazard endpoints specified under the EU's Directive on Dangerous Substances.[25] The second set of criteria under REACH defines "substances of very high concern" (SVHCs), which include:

- carcinogens, mutagens and reproductive toxicants (CMRs);
- persistent, bioaccumulative and toxic (PBT) or very persistent and very bioaccumulative (vPvB) substances; and
- "equivalent level of concern substances," such as those having endocrine-disrupting properties, which are to be identified on a case-by-case basis.

Some states have developed policies that focus on particular classes or uses of chemicals of concern. The state of Washington, for example, has established as a priority the identification and restriction of PBT chemicals, with an initial focus on mercury and brominated flame retardants[26] As one response to the growing contamination of fish–a key state resource–with mercury, the state of Maine has adopted a product focus, prioritizing the identification and elimination of mercury-containing products.[27] The emphasis on eliminating uses of mercury has extended the state's actions down the supply chain to focus on companies that use mercury in their products, and has led it to join forces with other states, both in the region and nationally.

Option 23: Develop a comprehensive "map" of the flow of chemicals in California

California could oversee a process to compile and integrate existing information and develop new sources of information to determine which chemicals are produced, imported, sold, used and disposed of in the state, in what quantities and forms, by which entities and for what purposes. This concept of a "chemical map" was introduced into the Conversation with California and is developed in substantial detail in Cal/EPA's Phase 1 Options Report of the Green Chemistry

[25] See a description of the Directive at http://ec.europa.eu/environment/dansub/home_en.htm. Annex VI of that Directive contains the actual classification criteria, available at http://ec.europa.eu/environment/dansub/pdfs/annex6_en.pdf.

[26] See Department of Ecology website, www.ecy.wa.gov/programs/eap/pbt/pbtfaq.html.

[27] See Department of Environmental Protection website at www.maine.gov/dep/mercury/products.htm.

Initiative[28] Such information would for the most part be made public, with appropriate provision for protection of legitimately confidential business information. While the state would mandate the process, it would also enlist various agencies, universities, local governments and industry.

California producers/importers, sellers and users of chemicals in the state would submit and periodically update information on production and processing (amounts, facility locations), uses (including in products), and post-use management. To improve efficiency and reduce the reporting burden on companies, they could be required to submit to the state any such information that they provide (whether voluntarily or under regulation) to other domestic or foreign jurisdictions. Such submissions would need to be supplemented, however, with additional or California-specific information identified by the state.

Such information would serve a variety of purposes, both environmental and economic. It could help to:

- identify key production and use sectors and their importance to the state's economic base, as well as likely sectors and sources characterized by having either relatively high dependence on chemicals of concern or relatively high levels of innovation in developing or using safer chemicals;

- improve understanding of chemical supply chains and the nature of and impediments to the flow of information along such chains;

- identify leverage points within and among sectors and supply chains that could be utilized to introduce and promulgate green chemistry concepts and practices;

- identify sources of potential release of and exposure to chemicals;

- identify key points of leverage and intervention in order to address potential risks associated with various activities over the life cycles of hazardous chemicals in the state; and

- identify and prioritize both chemicals of potential concern and those that pose low or no concern (which could serve as alternatives to riskier ones).

All industrial sectors that produce/import, sell, use and dispose of chemicals in the state would need to be involved in order to develop a comprehensive map. Existing programs that collect relevant information would need to be included, such as local and county-level hazardous waste and hazardous materials

[28] See Option DC-7 on pp. 12-14, available at www.dtsc.ca.gov/PollutionPrevention/GreenChemistryInitiative/upload/Phase_1_Options_Report_Chapters.pdf. While some aspects of this option could entail providing the information in geospatially relevant formats, the term "map" here is used primarily in a figurative sense.

programs, monitoring programs, etc. One example of existing information is that compiled under the state's Certified Unified Program Agencies (CUPA) program. This program operates at the county level and is currently focused on prevention of and emergency response to accidental releases of hazardous substances stored in the state. The program's scope would likely need to be expanded beyond its current inclusion of only hazardous waste generators, and its information would need to be electronically accessible. The state's pesticide use reporting program and its air toxics hotspots programs are other examples of existing programs that could provide useful information to this effort.

Information technology infrastructure (whether provided via the state, universities or private-sector parties) would need to be developed/expanded to enhance electronic submission capabilities, integrate information from various sources, and provide ready access.

The primary benefits of this option stem from developing a comprehensive picture of chemicals in California, and hence it should encompass essentially all chemicals in commerce in California. If necessary, implementation could proceed in phases, focusing initially, for example, on chemicals of concern identified by the state or other jurisdictions.

Option 24*:* Help advance the science of toxicology

Because of its size, history and culture, California likely has the most advanced infrastructure and capacity for testing and assessing chemical hazards and exposures of any state in the country. It is in a unique position, therefore, to address both longstanding and emerging concerns about the science used to test and assess chemicals.

Both the state of science and the state of knowledge about chemical hazards and exposures have evolved rapidly over the last decade. Demands for more and better information about chemicals have increased dramatically, even as traditional approaches to chemical testing and assessment are lamented in other quarters for being too costly and time-consuming, and too reliant on outdated methods and the sacrifice of laboratory animals. These dynamics introduce both new challenges and complexities, and new opportunities, to the fields of chemical toxicology and safety assessment. The challenges include the need to:

- integrate additional important health endpoints of concern into routine chemical testing, such as endocrine disruption and developmental neurotoxicity;

- consider emerging science, for example, new data that suggest that low-dose effects and the timing of exposure during development are important determinants of hazard;

- address longstanding concerns surrounding issues such as cumulative and aggregate exposures to multiple chemicals over extended periods of time; and

- account for the greater susceptibility, vulnerability or exposure of certain subpopulations (e.g., infants, the elderly, indigenous peoples).

Expansions in our understanding of the human genome and of cell biology have brought forth new methods that hold the promise of enhancing our ability to rapidly screen chemicals for adverse effects and cells for evidence of exposure to chemicals. Toxicogenomics, high-throughput *in vitro* screening assays and related approaches – once validated – could help to pave the way to faster, cheaper, less animal-intensive and potentially more accurate toxicology. In addition to further developing such methods, a critical remaining need is to "ground-truth" them – to ensure such methods yield accurate results reflective of actual effects in whole animals.

California is well-positioned to help move toxicology into the 21st century, given its long history and expertise in chemicals assessment. The state could play a critical role, in coordination with federal agencies, universities and private-sector initiatives, in both spurring and guiding the development, validation and application of new methods and testing strategies.

While this option is envisioned primarily as focused on toxicity testing, new science and approaches are also emerging for measuring and assessing exposure to chemicals. The state could consider an expansion of its efforts to develop biomonitoring data to include developing and implementing better methods for measuring dose and exposure.

Option 25: Target Chemical Uses of Concern Based on Hazard, Exposure and Risk

The same chemical (even a highly toxic or persistent one) may be used in different ways in various sectors of the economy. Some uses may trigger high concern; others little or no concern. This option calls for specific chemical uses to be subject to the science of green chemistry based on consideration of hazard, exposure and risk.

The degree of concern about a chemical use may be based on a consideration of both the intrinsic properties of the chemical (e.g., toxicity and persistence) and the use characteristics that are related to exposure and risk (e.g., the concentrations of toxic byproducts and waste generated in the manufacture or processing of a chemical, use of a chemical in closed versus open industrial processes, potential impacts of catastrophic release following accidents or

terrorist attack, the likelihood of worker exposure and the extent of worker protections such as engineering systems and personal protective equipment, the potential for discharge into the environment, the concentrations of toxic residues in consumer products, and the concentrations of toxic waste streams from product manufacture and disposal). Where data of sufficient quality can be obtained, the tools of lifecycle analysis (e.g., the entire carbon "footprint" of a chemical product, from manufacture to disposal), exposure assessment (e.g., biomonitoring, personal exposure assessment, source attribution, multi-media ecological modeling, ADME[29] characteristics, and bioaccumulation/biomagnification in aquatic or terrestrial environments), and risk assessment (e.g., threshold versus non-threshold dose-response functions, probability of accidents, risks to susceptible populations, background exposures to a chemical from multiple sources, and cumulative risks from multiple chemicals that operate in the body through a similar biological mode of action) can be used to screen chemical uses and identify those of concern.

Use-specific analyses may also – indeed, typically do – inform regulatory decisions (e.g., the same chemical may be permitted for some uses but prohibited for other uses).

In summary, under this option, a focus on chemical uses of concern may help set priorities for the application of green chemistry, including technology options analysis and substitution.

III. B. Regulations

California already has a complex framework of environmental laws and regulations to address pollutants in the air, water, soil and food. Stringent and innovative policies on air quality and public right to know, for example, have led the nation and the world and rewarded companies that meet the state's high standards. However, these laws were not intended to regulate, let alone transform, chemical production and use.

Some researchers and educators are concerned that generic standards and bureaucratic procedures could hamper green chemistry, rather than advance it. Many chemical manufacturers are skeptical of tighter rules and regulations – especially if they threaten existing markets or create a patchwork of differing state requirements without concomitant benefit.

On the other hand, a 2006 University of California report commissioned by the state legislature concluded that "weaknesses in the federal statute pertaining to industrial chemicals, the Toxic Substances Control Act of 1976, are a major

[29] ADME: absorption, distribution, metabolism, and excretion

obstacle to the emergence of green chemistry as a vibrant, viable economic activity"[30] While companies rarely advocate for regulation, mandatory requirements are not necessarily a burden for companies that are already ahead of the curve in managing chemicals and innovating safer ones. More importantly, regulations that improve the flow of information in the market and define and enforce minimum standards can remove the competitive advantage enjoyed today by companies that depend on hazardous chemicals.

This section presents several policy options that compel actions of this type, generally through the state's legal authority. The issues of information disclosure, alternatives assessment, and action on priority chemicals appear in other options of the Science Advisory Panel report. But the key distinction of the options below is that they rely on new or existing legal authority to drive changes. The following options build on experience, in California and elsewhere, with policies designed to spur technological innovation and transform markets. These include proposals to enable green chemistry to be recognized in the market, to promote the systematic assessment of alternatives, and to authorize Cal/EPA to set and enforce minimum standards. California could also play a constructive role in promoting major reform of federal chemicals policy.

Mandatory Information Disclosure

Like businesses and consumers, state regulators cannot make sound decisions about chemicals without basic information on their potential hazards and uses. Yet such information is frequently not available to regulators in California. It is notable that many public comments on the California Green Chemistry Initiative called for variations of compulsory public disclosure by companies that make and use chemicals[31]

Option 26. Require chemical manufacturers and importers in California to provide specific information about the hazards and uses of their products.

One of the key elements of the European Union's REACH legislation is a legal obligation to register thousands of chemicals over the next decade or lose access to the world's largest market. California could borrow this "no data/no market" approach by requiring companies that make and import chemicals in the

[30] Michael P. Wilson, et al., California Policy Research Center, Green Chemistry in California: A Framework for Leadership in Chemicals Policy and Innovation (Mar. 2006), available at http://www.ucop.edu/cprc/documents/greenchemistryrpt.pdf

[31] California Green Chemistry Initiative, "Phase 1: A Compilation of Options," January 2008. Note especially detailed comments from Dr. Joseph H. Guth, Science and Environmental Health Network, http://californiagreenchemistry.squarespace.com/display/ShowPost?moduleId=1564667&postId=293396#post293396 and from Californians for a Healthy and Green Economy (CHANGE) http://www.dtsc.ca.gov/PollutionPrevention/GreenChemistryInitiative/upload/CHANGE.pdf

state to provide certain information to Cal/EPA, downstream users, and the public. This information-forcing option places the duty of knowing and sharing information with chemical producers. Although the federal government also lacks an effective means for obtaining information and acting on industrial chemicals, this proposal is similar to the Cal/EPA's authority to require generation and disclosure of information on the toxicity and usage of pesticides as a condition of their application in California. While many details would need to be resolved, information on chemical properties such as persistence, bioaccumulation, and toxicity would be included. It would also include information on chemical uses and likely exposures. The process would take advantage of existing definitions of carcinogenicity, mutagenicity and reproductive toxicity and anticipate new information from endocrinology, ecotoxicology and other sciences. In addition, this proposal could require reporting of potentially confidential information about production, uses and trade in chemicals to be disclosed to appropriate parties, with appropriate protection for legitimate confidential business information.

Publicly-available information mandated under this option will help businesses, workers, communities and consumers to identify safer alternatives, and will support a variety of non-regulatory measures, such as procurement, targeted R&D, and voluntary management approaches. The information would also better inform California authorities in prioritizing and regulating chemical hazards, including potential restrictions and bans of chemicals in favor of safer alternatives.

Under this option, Cal/EPA would have broad authority to request additional information and to take action against companies that fail to comply. In addition to the compliance burden on chemical makers and importers in California, Cal/EPA would need to develop a process for receiving, assessing, and communicating this information with other authorities and the public. A standardized mechanism would be needed for the transmission of a reasonable set of information to downstream users. The program could be funded, in part, through fees paid by companies at the time the information is provided to Cal/EPA.

Option 27: Require companies to provide chemical information to Cal/EPA that they submit to other authorities

Companies that produce, use, sell, or distribute chemicals in California would be required to provide information to Cal/EPA that they have provided to other authorities. Like the mandatory reporting option above, this proposal is aimed at closing the data gap on chemical hazards and uses. But in contrast, this option does not force chemical manufacturers or importers to generate new data, only to provide Cal/EPA with relevant information that they have already reported to other authorities.

One of the most compelling reasons for this option is that many companies that manufacture chemicals used in California will soon submit information to the European Chemicals Agency as they register substances under REACH. In 2006, California exported $2.4 billion in chemicals to the EU, roughly ten percent of the state's $26 billion exports to the region.[32] Information submitted to national authorities in Canada and other countries could also be shared with the state. If these companies (and others based outside California) shared comparable information about chemical hazards, along with California-specific use information, it would strengthen the state's regulatory and other efforts to promote green chemistry. In this way Cal/EPA could fairly quickly and economically improve its knowledge of chemical hazards and uses in the state. Companies that have not reported relevant data to other authorities would be not be affected.

This information would include relevant hazard designations, specific information on human and ecological hazards, environmental fate, uses in California, safety measures, and potential alternatives. As with other proposals, Cal/EPA would need to establish a process for gathering and organizing this information, for determining which information should be publicly available, and for protecting legitimate confidential business information.

Option 28: Require product manufacturers and importers in California to disclose chemical ingredients

As more chemicals are detected in human blood and breast milk, there is greater scrutiny of product use and disposal as important routes of human exposure. However, existing product labeling requirements and material safety data sheets (MSDSs) reveal very little about the chemical components of common products, whether in formulations (i.e., chemical mixtures) such as cosmetics or household cleaners, or in finished goods like toys, clothing, and automobiles.

California could address this data gap by requiring manufacturers to provide the state with a list of all ingredients in their products. The exact composition, such as ingredients by percentage, would not be required. The state would require a list of ingredients, updated annually, in retail products, possibly beginning with select categories, such as children's products, cleaning products, and office products. California's long experience with Proposition 65 provides a precedent for requiring business to discover and disclose chemicals in their products or processes.[33] However, this proposal would go beyond substances on the existing state list of carcinogens and reproductive toxics.

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[32] US Census Bureau. Foreign Trade Statistics: State Exports for California, 2007.

[33] The Safe Drinking Water and Toxic Enforcement Act of 1986, is better known as Proposition 65.

Mandatory disclosure of chemical ingredients enables wholesalers, retailers, consumers and others to differentiate products on the market that embody green chemistry approaches. However, it is not realistic to expect individual consumers to study detailed lists of ingredients; few people would attempt to decipher the chemical names or to distinguish greener chemicals from others. However, if this information is credible and easily accessible, it will attract the attention of third parties, such as consumer, environmental, and health organizations, that are capable of reviewing the information and providing practical guidance. Examples of existing product databases in the United States include the "Skin Deep" database, created by the nonprofit Environmental Working Group, with information on over 27,000 cosmetic products and more than 7,200 chemicals[34] In 2007, a partnership led by the nonprofit Ecology Center, launched a database of 1,200 toys based on an analysis of specific ingredients[35]

The state would need to establish a process for collecting and organizing this information and making it publicly available without divulging legitimate trade secrets. The utility of this effort would expand if other states coordinate efforts to gather, assess and disseminate ingredient information. This would be greatly facilitated by standardized electronic forms, to avoid re-entering information. It would be up to third parties to develop product-rating schemes and other consumer guides based on the state's ingredient database.

Mandatory Alternatives Assessment

In addition to reporting requirements, California could require producers and users of hazardous chemicals and processes to undertake assessments of alternatives (also known as technology options analyses) identifying greener chemistry and/or engineering practices that: (1) could be adopted to provide environmentally-sounder and inherently safer final products, intermediates, inputs, and processes; and, (2) could be developed by the producer, user, their suppliers, academia, research institutions, or national or state efforts.

Option 29: Require chemical makers and users to systematically identify and consider safer alternatives

While advancing the science and practice of alternatives assessment is featured in other options detailed in this report, this proposal is distinct in that it would create a legal obligation on chemical producers and users. States that require technology options have achieved faster adoption of environmentally cleaner and

[34] Skin Deep: Cosmetics Safety Database, Environmental Working Group, Washington, DC. http://www.cosmeticsdatabase.com/

[35] The Consumer Action Guide to Toxics Chemicals in Toys. A Project of the Ecology Center. http://healthytoys.org

inherently safer technologies than states that do not[36] Massachusetts, for example, requires the reporting of state-of-the-art toxics use reduction plans from firms obligated to report under the Toxics Use Reduction Act of 1989. New Jersey has a similar statutory requirement. The costs of this regulatory option are financed, in part, through fees on chemical production and use, administered by the state.

Mandatory alternatives assessment would encourage chemical producers, users, and suppliers – and others in the supply chain – to consider more seriously adopting or developing alternative technologies. By requiring submission of results of the assessments to Cal/EPA, the state can amass useful information and make it accessible to industry, government, and citizens. The results of alternatives assessments can also identify needs and opportunities for regulation, innovation, and development.

The requirement would be placed on producers and users of a designated set of hazardous chemicals. The state would monitor the reporting, collection and dissemination of the information, while protecting legitimate trade secrets. In addition, trade associations, state technical assistance offices, research centers and universities could assist companies in conducting alternatives assessments and guide them toward green chemistry, engineering and design solutions.

Authorize Cal/EPA to adopt regulations to spur green chemistry

The decentralized boards, departments, and offices under Cal/EPA, including the Department of Toxic Substances Control, the California Air Resources Board, and the Office of Environmental Health Hazard Assessment, currently have some legal authority to act in ways that can increase demand for green chemistry. However, the hazards of most industrial chemicals permeate the legal and institutional silos for regulating air, water, waste, workplaces, and consumer products in California. As a result, the state faces practical challenges in advancing green chemistry through piecemeal legislation and programs.

Option 30: Authorize Cal/EPA to phase out hazardous chemicals

Because of its unique history, Cal/EPA is largely an oversight agency for state regulatory bodies that does not itself wield regulatory authority. Existing state regulatory agencies have separate authority over air, hazardous waste, solid waste, water, and worker exposure. But to be effective, green chemistry solutions should take into account the full chemical life cycle, including all environmental

[36] B. Karkkainen, ''Information as Environmental Regulation: TRI and Performance Benchmarking, Precursor to a New Paradigm?'' Georgetown Law Journal 89 (2001): 257–370 and N. A. Ashford and Charles C. Caldart, Chapter 13: Policies to Promote Pollution Prevention and Inherent Safety in Environmental Law, Policy, and Economics:Reclaiming the Environmental Agenda, (2008) MIT Press; Cambridge.

media and exposures among workers and communities. The state legislature could give Cal/EPA explicit authority to ensure that actions taken to address health and environmental problems at any one of these points in the life cycle do not inadvertently create new problems at other points. Though challenging to implement, this could produce a better-integrated regulatory approach for managing chemicals, products, and applications, and could reduce the likelihood of regrettable substitutions.

California has learned that it is difficult to use single-medium regulations to control or eliminate the use of dangerous chemicals. For example, the California Air Resources Board is able to regulate chemicals if they are volatile organic compounds (VOCs) or if they are already on lists of toxic air contaminants. However, potential substitutes for these substances can also be dangerous. In some cases, less toxicity information is available for substitute chemicals, so they do not appear on toxic substances lists. At present, emerging chemicals can be on the market for years before enough information is generated that triggers a listing as a hazardous air pollutant or hazardous waste.

California's experience with solvents is a case in point. Solvents are a diverse group of chemicals with multiple applications and significant potential for occupational and environmental exposure. Over the last decade many companies have introduced alternatives to ozone-depleting substances and chlorinated solvents. In many cases, these alternatives were not regulated but were later shown to be toxic. n-Propyl bromide, for example, is used in metal and electronics cleaning, adhesives, and aerosol products, yet emerging evidence suggests that it can damage the reproductive and neurological systems. Another emerging solvent, "D5," is used in cleaning and in consumer products and is being marketed for use in dry cleaning. Recent evidence indicates that it produces cancer in laboratory animals.[37]

Of course, the potential danger of replacing one problem with another is not unique to solvents. By authorizing Cal/EPA to regulate using a multi-media approach that includes occupational, community, consumer, and environmental exposures, California would more effectively promote the adoption of green chemistry solutions while addressing a broad set of existing problems.

Option 31: Phase out chlorinated solvents

The use of certain hazardous chemicals is inappropriate when the safety and feasibility of preferable alternatives has been demonstrated. In such cases, California should take prompt action, backed by enforceable regulations. The continued use of chlorinated organic solvents represents such a case. Taking

[37] http://www.oehha.org/multimedia/green/index.html

coordinated action on this group of chemicals and applications can serve as a template for phasing out other dangerous chemical classes.

Chlorinated solvents still in use in California include carcinogens such as trichloroethylene (TCE), perchloroethylene (PERC) and methylene chloride. These and related substances are used in numerous applications, including metal cleaning, paint stripping, film printing, dry cleaning and consumer products. Efficiently phasing out such uses reduces risks to workers, communities and consumers – provided that the alternatives do not introduce new problems.

In some cases, California already has sufficient authority to take action on hazardous chemicals. One example is found in the regulation of cleaning products by the regional air quality management districts under the California Air Resources Board (ARB). The ARB has also adopted state-wide regulations to phase-out chlorinated solvents in aerosol products in the vehicle repair industry, and to phase out the use of PERC in dry cleaning. There are safer and cost-effective alternatives for most, if not all, of the other applications where chlorinated solvents are currently used. DTSC could develop more comprehensive regulations to phase out other chlorinated solvents. In addition, DTSC could sponsor independent research to develop and demonstrate alternatives for specific uses and conduct outreach to affected companies.

Option 32: Require all air quality management districts to adopt SCAQMD regulations on cleaning products

The South Coast Air Quality Management District (SCAQMD) has jurisdiction over stationary sources of criteria air pollutants, including reactive hydrocarbons such as volatile organic compounds (VOCs) in a region with a population of more than 15 million people. SCAQMD has established strict rules on cleaning products to prevent releases of reactive hydrocarbons that contribute to photochemical pollution, or smog.

SCAQMD regulations affecting thousands of Southern California facilities are already demonstrating the feasibility of low-VOC alternatives, including water-based, soy-based and acetone cleaners. These restrictions have affected an extensive range of cleaning operations used by thousands of facilities in southern California, including vapor degreasing, cold cleaning, hand-wipe cleaning, repair and maintenance cleaning, screen and lithographic equipment cleaning, and cleaning of adhesive and coating equipment. Nearly all auto repair facilities in Southern California, for example, have converted from mineral spirits to water-based cleaners; printers are also converting to safer alternatives. As previously noted, there is a continuing need for vigilance to ensure that alternatives do not pose new or unforeseen dangers, particularly for substances that have not been adequately assessed.

Extending these regulations across the state would substantially reduce VOC emissions, while also reducing exposures among workers and communities to toxic chemicals. Under this option, SCAQMD staff could provide guidance to the other air districts in implementing the regulations.

III. C. Incentives to Boost Demand for Green Chemistry

A 2002 report by the Organization for Economic Cooperation and Development (OECD), which includes the United States, noted: "It is essential that any sustainable chemistry technology or product be competitive in the marketplace, at least in the long term. However, some of those technologies, even if they are beneficial in the long term, will not be able to survive economically without incentives."[38]

The Science Advisory Panel identified a range of options that are intended to boost demand for greener chemicals, products, process and technologies. The first group (Information and Tools) aims to increase demand for green chemistry by providing access to information and developing tools that help producers, sellers, purchasers and consumers of chemical products and services to select greener alternatives. The second group (Market Promotion of Green Chemistry) aims to drive demand by promoting the adoption of greener products in the marketplace.

Information and Tools

Option 33: Provide retailers with access to guides for selecting greener alternatives to toxic products, via a retailer clearinghouse.

This option recognizes that retailers can play a role in increasing demand for goods and services informed by green chemistry criteria. The first step, which could be undertaken by a group of retailers of green products and services, would require establishing and vetting criteria for comparing products or services in a given category. Additionally, references to supporting documentation and a process for airing and resolving disputes would be provided. Once established, the criteria would be made available to other organizations that rate and/or procure products/services (e.g., Consumer Reports, Kaiser Permanente) for their use in identifying qualifying products/services.

[38] Organisation for Economic Co-operation and Development, "Need for Research and Development Programmes in Sustainable Chemistry," March, 2002. http://www.oecd.org/dataoecd/9/55/2079870.pdf

The association could then make such information available via a website along with links to:

- sites of reliable organizations that compare products/services (examples given include the Healthy Building Network's site on alternatives to PVC (www.healthybuilding.net/pvc/PVCFreeAlts.html) or the U.S. EPA's Energy Star Program (www.energystar.gov/); and

- procurement policies and programs that favor greener products, e.g., those of state government or company procurement policies (as an example, see description of Kaiser Permanente's approach at www.purchasing.com/article/CA6511767.html).

Such a program could help advance green chemistry in California by enabling retailers to identify greener products/services. It would also provide retailers' buyers and sustainability specialists with access to the growing body of available research.

Option 34: Develop a "green scorecard" for chemical products that lets both producers and consumers know which products truly are greener than others.

This option is motivated by the need for transparency and consistency in how "green" products are identified and marketed. This would benefit both producers and consumers by allowing more informed choices as to which products/services truly are greener than others. The intent is to provide an incentive to drive demand for such products and services. Thus, producers could see how to make their products more attractive to those consumers (including the state) who have an interest in green procurement.

For a scorecard to be effective and credible, it would have to be prepared by a group with the appropriate expertise, who are not conflicted by other professional relationships. The scorecard preparation methodology would have to be transparent, rigorous and subject to independent peer review. A desirable attribute of any scorecard is that it not set a ceiling, but rather that it drive continuous improvement toward goals, which may be raised over time as needed.

The state could start the process of developing a scorecard and recruit participants. But it would need to take care to maintain the independence of the panel and its determinations and allow the work to proceed without political interference. Companies producing consumer products and services would be most directly and immediately affected. State or other organizations' purchasing practices that are subject to public pressure to move towards greener products would likely be shifted as well.

There are a number of scorecards that have been developed to focus on specific industry sectors or product categories. For example, the U.S. Green Building Council's LEED rating system is an example of how specific criteria can serve the needs of producers and consumers of environmentally-preferable approaches in building construction and maintenance[39]

Option 35: Screen chemical product formulations for safety, health and environmental preferability, based on full ingredient disclosure by the producer to the screener.

This option would entail the development and use of protocols and/or software tools to assist procurement staff in state government (and potentially other organizations) to screen product formulations expeditiously within a given category against specific criteria. The criteria could either be related to characteristics of concern (e.g., chemicals that are persistent, bioaccumulative and toxic) or to positive characteristics (e.g. rapid biodegradability and low aquatic toxicity). In addition to directly increasing demand for greener products, it would also signal to producers desirable and undesirable product attributes, hence serving as an incentive for continuous improvement.

The state could either adopt and adapt available software or develop its own. For a producer to have its product(s) screened, it would need to have knowledge of or learn from its suppliers the full composition of its product and make that information available to the screener (under appropriate confidentiality agreements). The outcome for products with positive characteristics may be preferred purchasing. The outcome for products with characteristics of concern may range from a decision not to purchase the product, to initiation of an alternatives assessment, to a decision that the ingredients not meeting the criteria might be needed for specific applications or uses of the product but not for other applications/uses.

Market Promotion of Green Chemistry

Option 36: Incorporate green chemistry criteria into state procurement processes.

One of the most direct ways for California to support the adoption of green chemistry is through its powerful role as a consumer of goods and services. This proposal would leverage the collective purchasing power of the Department of General Services (DGS) and other state agencies. The Environmentally

[39] See http://www.usgbc.org/DisplayPage.aspx?CategoryID=19

Preferable Purchasing program, co-sponsored by Cal/EPA and DGS, has already boosted the state's investment in green buildings[40] Enlarging the scope of this and other such programs could enable green chemistry solutions to be recognized and considered in ongoing decisions, thereby expanding demand.

As an example, the City and County of San Francisco is already making progress in greening their procurement under the 2005 Precautionary Purchasing Ordinance[41] In that effort, the city's Department of the Environment identified ten "targeted product categories" (e.g., computer equipment, lighting, cleaners, paints) and established a process for developing specifications for use in city contracts.

In drawing lessons from this municipal experience, the state could adopt complementary criteria and product categories based on the twelve principles of green chemistry to strengthen the signal to the California market. This proposal would be enhanced by training state procurement officers and publicizing new opportunities for vendors and service providers offering green chemistry solutions. These procurement efforts could benefit from other proposals in this report concerning access to information, product scorecards, and other tools for assessing products.

Option 37: Provide marketing exposure for green chemistry products and processes.

California has had impressive success, both in-state and globally, in marketing specific products of the state. Millions of Americans are likely to recognize the high-profile advertising campaigns for California raisins or "Real California Cheese."[42] By developing a proactive marketing strategy for green chemistry processes and products, California would help educate businesses and consumers on the availability of products that embody genuine green chemistry solutions. This would also help these products succeed in the market and be sustained.

Once greener products and processes are identified, California would identify appropriate audiences (e.g., demographics) and the most effective marketing vehicles (e.g., television, print media, radio, Internet). The state could create the marketing tools directly or manage an independent consultant to do the same.

[40] http://www.ciwmb.ca.gov/epp/TaskForce/Charter.htm

[41] San Francisco Department of the Environment "Review on Implementation of San Francisco's Precautionary Purchasing Ordinance, July 2005 – July, 2007," July 24, 2007. See: http://www.sfenvironment.org/downloads/library/pporeviewjuly0507.pdf

[42] http://www.realcaliforniacheese.com

Option 38: Create a web-based marketplace for greener chemicals and products

California could facilitate the market for green chemistry solutions by contributing to the development of an Internet-accessible database. This could enable companies to identify less-hazardous substances while protecting legitimately proprietary information.

There are good existing models for web-based marketplaces such as online databases containing information on raw materials uses in industrial and institutional cleaners. For example, CleanGredients^{SM} was developed in partnership with the U.S. EPA's Design for the Environment Program and a group of stakeholders representing formulators, suppliers and independent experts[43] This tool assesses the environmental and human health attributes of chemicals based on their functionality, such as with surfactants, solvents, and chelating agents. Third-party verification can provide a check on the validity of the data while maintaining legitimately confidential business information.

California could build on this experience by establishing technical criteria, possibly through a transparent stakeholder process, and defining priority chemical functionalities or products for attention. The resulting web-based marketplace would help downstream users to identify chemicals and products that meet the criteria. At the same time, it would provide a means for suppliers of chemicals that meet the criteria to tout their advantages.

This proposal could involve new or existing institutions in California, such as are described in this report. Furthermore, California could cooperate with other states to make this web-based tool applicable over a wide geographic region. This could also be designed to reinforce state procurement policies, aligning the flow of raw materials in the supply chain with desired product attributes. By creating a publicly-available database containing positively-defined chemicals and materials, California would help to facilitate green chemicals in the supply chain and reduce cost.

[43] See: http://cleangredients.org/home

IV. A Call for Action

IV. A. Revisiting the Options: Do they cover the range of identified needs?

In Section I.D., we described a framework (Matrix 1) for analyzing options along several dimensions:

- providing means to promote both supply of and demand for green chemistry;
- addressing data gaps, safety gaps and technology gaps in current policies;
- fulfilling core functions of a comprehensive chemicals policy; and
- together encompassing a balanced portfolio of options utilizing a broad range of policy instruments available to the state, from establishment of state policy to use of regulatory authorities to voluntary incentives and use of market incentives to support for green chemistry education and research.

While the originally anticipated exercise of mapping all of the Science Advisory Panel's several dozen options onto the matrix proved impracticable, this section provides a more qualitative description to demonstrate that, taken together, the options do address policy needs across all of these dimensions.

Mix of supply- and demand-side options:

The Science Advisory Panel acknowledged from the outset that advancing green chemistry in California will require utilization of policy instruments to increase both supply of and demand for greener chemicals (and associated processes, technologies and approaches). Supply-side options – including initiatives in education and research and economic incentives – help to facilitate the creation and dissemination of greener chemicals, processes and technologies. Demand-side options help to ensure the economic viability of greener chemicals by better informing the market, leveling the playing field on which greener options compete, and creating a regulatory climate that drives both the development and the adoption of greener alternatives. Below, we summarize all of the Panel's options according to the supply-demand rubric, referring to the categories of options that correspond to this report's subsections from Sections II and III.

Supply-side Options. Science Advisory Panel options on the supply side include those aimed at:

- instilling green chemistry into education (Section II.A.), including through both general and specialized education curriculum development; science teacher training; establishment of and support for faculty positions and

fellowships and internships in green chemistry; and introduction of green chemistry concepts into business school education and vocational and workforce training programs.

- supporting research and innovation in green chemistry and engineering (Section II.B.), by inventorying current efforts and identifying critical gaps; providing funding and institutional support for green chemistry in higher education institutions; targeting tax incentives, patent assistance and intellectual property protection policies and programs to maximize both innovation and public benefit arising from public research dollars; facilitating appropriate industry-university partnerships; and aiding in the commercialization of green chemistry products through access to testing and assessment tools and facilities and the creation of innovation centers to assist entrepreneurs and small businesses.

- building green chemistry capacity through development of tools, methodologies and strategies for developing greener chemicals (Section II.C.), by advancing the science of alternatives assessment; and establishing an independent institute to conduct such assessments and develop and test safer alternatives to chemicals of concern.

- providing incentives to industry and recognition of its efforts (Section II.D.), through voluntary actions such as implementation by companies of chemical management systems, promotion of green chemistry by industry associations, improved value chain communications; establishment of green chemistry innovation awards and competitions and targeted research challenges; development of a green chemistry web portal to share innovations and resources; and adding green chemistry to state technical assistance programs.

Demand-side Options. Science Advisory Panel options on the demand side include those aimed at:

- identifying and prioritizing chemicals or chemical uses of concern (Section III.A.), through establishment of a state policy and a process to develop specific criteria to be used to identify such chemicals; gaining a thorough understanding of who chemicals are produced, used and disposed of in the state via chemical "mapping;" and advancing the science of toxicology testing to facilitate more effective and efficient identification of chemicals of concern and safer alternatives.

- developing, improving and effectively employing regulations (Section III.B.), including mandatory information disclosure on chemical hazards and uses and product ingredients, and provision to the state of information companies submit to other governments; requirements for companies to seek safer alternatives and conduct alternatives assessments for hazardous chemicals and processes; and granting broader regulatory

authority to the state to drive green chemistry innovations, address the full life cycle and multimedia impacts of chemical products, phase out particularly hazardous chemicals such as chlorinated solvents, adopt statewide the most stringent standards for certain classes of products such as those releasing VOCs.

- developing incentives to boost demand for green chemistry (Section III.C.), including by providing tools and access to information via clearinghouses, chemical scorecards for ranking products, and screening of chemical product formulations and ingredients; and promoting markets for green chemistry products via state procurement programs, green product marketing campaigns, and web-based marketplaces.

Addressing all three gaps in data, safety and technology:

Most options aimed at addressing the demand side target the data gap and safety gap, whereas supply-side options tend to focus more on addressing the technology gap. Examples of options relevant to each of the three gaps are provided below.

Data gap: Options to identify and prioritize chemicals of concern directly address current gaps in data on chemical hazards, uses and exposures. Some of the regulatory options, especially those mandating information development and disclosure, also address this gap. Options designed to increase the utility of and access to chemical information – clearinghouses, scoring and screening methodologies, etc. can be used to bridge the data gap as well.

Safety gap: Mandating alternatives assessment to identify safer substitutes for hazardous chemicals and processes is an option that builds a foundation for bridging the safety gap. Application of regulatory authority to restrict the use of hazardous substances also directly addresses this gap. Direct promotion of chemicals and products identified as greener via procurement programs and marketing initiatives can help to close the safety gap.

Technology gap: By spurring the supply side of the green chemistry equation, efforts to foster and provide funding and institutional support for green chemistry education, research, and innovation, and to spur, support and reward industry for voluntary efforts, all seek to close the technology gap by making products of green chemistry more widely available.

Fulfilling core policy functions:

Matrix 1 identifies a set of core policy functions, listed below, to each of which one or more of the Panel's options directly apply. Examples include the following:

- Identify/ prioritize chemicals of concern: The options in Section III.A. directly help to meet this policy need.

- Track chemical production and use: The chemical mapping option and use reporting and disclosure options are among the means offered to more effectively track chemicals.

- Collect and develop data: Regulatory requirements to develop and disclose information, and options to advance research at universities and through appropriate industry-university partnerships can help to fulfill this function.

- Share/protect information: Regulatory (e.g., mandatory disclosure) and voluntary efforts (e.g., value chain communication facilitation) designed to increase access to information address the function of sharing information. Patent assistance and intellectual property ownership policies address the need to protect certain types of information.

- Assess chemical hazards/ exposures/risks/uses: Examples of options addressing this function include the development of criteria to identify chemicals of concern and of better tools and methods for toxicity testing and for ranking and screening of chemicals and chemical products.

- Control chemicals of concern: This function can be met through options proposed to provide the state with broader authority to restrict the use of chemicals of concern, including by addressing specific types of chemicals or chemical products, specific sources of release or exposure, or the full product lifecycle.

- Assess alternatives/options: Options relevant to this need include mandatory alternatives assessment, the advancement of the science of such assessments, and the sharing of information on safer alternatives.

- Innovate toward safer chemicals: Improvements in education, support for public- and private-sector research and innovation, awards and competitions, and technical assistance for green chemistry are among the options that can facilitate innovation toward safer chemicals.

Relevance of the identified options for behavioral change:

In Section I.D., we emphasized the need to influence the behavior of industry, academia, government, and other stakeholders to advance green chemistry and engineering by affecting their willingness, motivation/opportunity and capacity for change. Matrix 3 below represents a 'mapping' of the options identified in this report to determinants of these three behavioral factors. As explained above, they address key gaps in knowledge from both supply- and demand-side

interventions. What Matrix 3 reveals is that there are a large and varied number of interventions affecting willingness and capacity. However, the smaller number of motivation/opportunity interventions are crucial in achieving behavioral change, especially regulation requiring information generation and reporting, regulation requiring technological change, and demand creation. Without market (and regulatory) pull incentives, technology push interventions alone can be expected to have limited success.

Yielding a balanced portfolio:

As the descriptions above make clear, the Science Advisory Panel has identified a broad range of options that can work together to advance green chemistry in California. No single option or category of options is likely to suffice. Rather, the state needs to draw from all of the policy instruments available to it, and assemble and utilize a full and diverse set of options, if it is to create both supply and demand for green chemistry, bridge key gaps hindering current efforts, and effectively carry out the core functions of a comprehensive chemicals policy.

Determinants of Change -- Leverage points to encourage the needed (governmental, private-sector, and societal) changes through green chemistry and engineering

KEY CHANGE FACTOR	INTERVENTION TYPE	SPECIFIC ACTIVITIES
Willingness		
-towards changes in production (flexibility)	address static mind-sets/encourage risk-taking	6, 8, 15
-influenced by an understanding of the problem (i.e., what aspects of the technology need to be changed)	information dissemination/educational initiatives	1, 6, 13, 16, 17, 22, 23, 24
-influenced by knowledge of options or solutions (diffusion)	information dissemination/educational initiatives/databases	3, 4, 9, 13, 17, 19, 21, 33, 34, 35
-influenced by the ability to evaluate alternatives	methodology development and capacity-building	1, 3, 4, 14, 20
Opportunity/Motivation		
-gaps in technological/scientific capability (compared to others in existing markets)	databases and demonstration/showcase projects	33, 34, 38
-possibility of economic cost savings in existing markets or new/expanded market potential	perform and disseminate cost-benefit and market analysis	35, 34, 36, 38
-regulatory requirements necessitating technological changes	regulatory initiatives	30, 31, 32
-consumer/worker/societal demand	require reporting to government/public	26, 27, 28, 29 35, 36
(making new markets)	enhance marketing/demand for greener technology	35, 37, 38
Capacity		
- influenced by an understanding of the problem (i.e., what aspects of the technology need to be changed)	information dissemination/educational initiatives	1, 6, 13, 16, 17, 22, 23, 24
- influenced by knowledge of options or solutions (diffusion)	information dissemination/educational/initiatives/databases	3, 4, 9, 13, 17, 19, 21, 33, 34
- influenced by the ability to evaluate alternatives	methodology development/technical assistance/capacity-building	1, 3, 4, 14, 20, 38
- resident/available skills and capabilities (for innovation)	capacity-building, education/training	3-8, 10, 12, 16, 18
- outside assistance	state offices of technical assistance/university-based projects	1, 11, 12, 16

IV. B. Agents of Change

Agents of change are present throughout the state of California and include actors in government, industry, universities, and not-for-profits. Key conditions for behavior change are in place.

First, as evidenced by the process that resulted in this report, there is a willingness to change. California has worked to understand the problem of chemicals policy and the appropriate role of green chemistry and engineering in the evolution of its policies. It is engaging in a process to develop and evaluate new approaches and chemical policies that embody principles of green chemistry and engineering. At this point, the question is not whether but rather how the state will move forward with a green chemistry initiative.

Second, on a statewide basis, there are major opportunities that motivate the adoption of green chemistry initiatives. Strong regulation of air, waste and water in California over the last several decades has resulted in one of the most health-protective regulatory climates in the world. This regulatory environment creates a favorable environment for the development of alternative means of production that require fewer permits, inspections and controls on pollution and waste disposal. At the same time, California has an active and well-informed citizenry that has created demand for green chemistry and engineering at the grassroots level, among workers, and at the state's colleges and universities

Finally, the state of California intrinsically has the capacity to undertake a major green chemistry initiative. Through the convening of this Panel and other processes, it has developed a fundamental understanding of the problem and has identified a number of options for change. California possesses a wealth of skills and capacities that provide a foundation for building a major initiative in this area.

California is undertaking a thorough assessment of green chemistry and engineering in the state, one informed by the engagement of multiple stakeholders including industry, environmental groups, local government, and scientists, as well as by the input of external experts.

California can build the momentum for change based on a foundation of expertise and ability that is already present in the state. In terms of government, DTSC has much experience with providing expertise and consultation in pollution prevention, waste reduction, and energy conservation. It, along with other Cal/EPA entities (most notably the Office of Environmental Health Hazard Assessment), has strong expertise in toxicology, risk assessment and chemistry. Cal/EPA also has a strong reputation for bringing together university scientists, stakeholders and industry groups to achieve ambitious goals reasonably, effectively and in a timely fashion (for example, the Proposition 65 listing activities; development of regulations by the California Air Resources Board, and

identification of hazardous waste priorities by DTSC). With training and refocusing of effort, these skills and abilities can be harnessed to the service of green chemistry. Likewise, California's local governments have an enormous pool of expertise and capacity to participate in new green chemistry efforts.

California's industrial sector is known for being innovative and embracing new technologies. The history is instructive: aerospace, newer agricultural technologies, petrochemical manufacturing, medical care, biotechnology, microprocessors, software development, stem cell research and now climate mitigation technology. Again and again, California's economy has benefited from a willingness of industry to innovate and to adopt new ideas. It is likely that California's industry will respond positively to new opportunities to adopt green chemistry and engineering alternatives, for which there will be demand not only in California but also among informed consumers in the rest of the U.S., as well as markets in Canada and Europe that are under new, stricter chemical regulatory regimes. Once again, California will benefit economically through its willingness to innovate.

California has a world-class system for higher education, which also provides a foundation for a major initiative in this area. In particular, California has led in areas of science and social sciences that are important to green chemistry and engineering, not only chemistry and engineering but also in the environmental and health sciences that are closely related to this area. Academics in California have been thought leaders on chemicals policies issues worldwide, and their continued engagement will be critical not only to the development of educational programs but to providing scientific input to efforts by state government and industry.

Finally, California has an engaged and environmentally-conscious public that is willing to make environmental issues a priority. Participation in the green chemistry initiative by members of the public and stakeholder groups is proof of the ongoing commitment to the process and the priority that they give this issue. Only the continued engagement of stakeholders across a wide swath of the state will assure that an initiative is not only started but also sustained over time, and receives the support that will be required for its continued success.

IV. C. California's Opportunity for Green Chemistry Leadership

Reflecting the diversity of backgrounds, perspectives and expertise of the Science Advisory Panel itself, this report presents California with a broad range of options to consider as it endeavors to advance green chemistry. What is perhaps most striking about these options is that they provide means not only for government, but for each of the myriad stakeholders and actors to contribute to this ambitious enterprise. These options highlight critical roles and opportunities for chemical producers and users in diverse business sectors, technology developers, academic researchers, educators at all levels, purchasers and

sellers of chemicals and chemical products, end consumers and the broader public.

The state can both act directly and help to empower and guide the actions of all of these other players. Its roles can include providing critical support for education, research and innovation in green chemistry; providing incentives and recognition for voluntary industry initiatives; driving the development of and access to more and better information, scientific methods and analytic tools; setting clear policy objectives; and effectively employing regulation where needed.

The field of chemistry itself provides a fitting metaphor for what is ultimately needed to advance Green Chemistry in California. The chemist's aim is to combine reagents to yield a desired end product as effectively and efficiently as possible, minimizing unwanted byproducts and waste. To do so, chemists often seek out and utilize ***catalysts*** to increase both the rate and yield of the desired chemical reaction. What makes a catalyst special is that, while it may be chemically transformed during the reaction, it is not consumed and is regenerated at the end of the reaction. Because of this, addition of only a small amount of a catalyst can be enough to drive the desired reaction.

Consider both the range of players and the diversity of available options to be the mix of chemicals in a reaction vessel. The state of California has a golden opportunity to become the catalyst that draws together and creatively combines the various ingredients needed to advance Green Chemistry. The members of this Science Advisory Panel hope that our report provides a useful contribution to achieving this noble end.

Appendices

Appendix A: Science Advisory Panel Member Biographies

Chair: John Warner, Ph.D.
The Warner Babcock Institute for Green Chemistry

After establishing the world's first Green Chemistry Ph.D. program, Warner now directs a large research group working on a diverse set of projects involving green chemistry using principles of crystal engineering, molecular recognition and self-assembly. He is the editor of the Journal "Green Chemistry Letters and Reviews." He was awarded the American Institute of Chemistry's Northeast Division's Distinguished Chemist of the Year for 2002, and the Presidential Award for Excellence in Science, Mathematics and Engineering Mentoring in 2005. His recent patents in the fields of semiconductor design, biodegradable plastics, personal care products and polymeric photoresist films are examples of how green chemistry principles can be immediately incorporated into commercially relevant applications. Warner is co-author of "Green Chemistry: Theory and Practice."

Vice Chair: John R. Balmes, M.D.
University of California San Francisco and Berkeley

John Balmes is the Director of the Center for Occupational & Environmental Health at the University of California, San Francisco and University of California, Berkeley. He is a pulmonary physician by training, Professor of Medicine at UCSF, and Chief of the Divisions of Occupational and Environmental Medicine at San Francisco General Hospital. Balmes leads a group of investigators at UC Berkeley and UCLA to assist in developing a national program linking environmental hazards with health outcome data to track diseases that are potentially related to environmental exposures.

Paul Anastas, Ph.D.
Yale University

Anastas serves as the Director of the Center for Green Chemistry and Green Engineering at Yale University. He served as Chief of the Industrial Chemistry Branch at the U.S. Environmental Protection Agency and Director of the U.S. Green Chemistry Program, where he is credited with establishing the field of green chemistry.

Nicholas Ashford, J.D., Ph.D.
Massachusetts Institute of Technology

Ashford is the Director of the Technology & Law Program at the Center for Technology, Policy & Industrial Development at the Massachusetts Institute of Technology. He is an advisor to the United Nations Environment Programme and is the Legislation, Regulation and Policy Editor of the Journal of Cleaner Production. Ashford has developed methodologies for decision-making in chemical regulation and has extensively investigated the effects of regulation on technological innovation in the chemical, pharmaceutical and automobile industries.

Eric J. Beckman, Ph.D.
University of Pittsburgh

Beckman serves as Professor of Chemical Engineering and Bayer Professor and Chair at the University of Pittsburgh. He is also Co-Director of the Mascaro Sustainability Initiative. Prior to joining the University of Pittsburgh, he held positions at Monsanto Plastics & Resins, Union Carbide’s Silicones and Urethanes Intermediates Division, and held a postdoctoral research appointment at Battelle’s Pacific Northwest Laboratory. Beckman’s research is in the use of carbon dioxide as either a solvent or raw material and polymer chemistry & processing.

William Carroll, Ph.D.
Occidental Chemical Corporation

Carroll is a Vice President of Occidental Chemical Corporation and an Adjunct Industrial Professor of Chemistry at Indiana University. He has served on expert groups commissioned by the states of Florida and Oregon. He contributed to the United Nations Environment Programme's Best Available Techniques/Best Environmental Practices Guidelines for implementation of the Stockholm Convention on Persistent Organic Pollutants. In 2005 he was President of the American Chemical Society.

Gail Charnley, Ph.D.
HealthRisk Strategies

Charnley is a Principal at Health Risk Strategies with over 30 years experience in the biological, chemical and social policy aspects of environmental and public health protection. She lectures frequently on science policy issues and is the author of numerous reports evaluating the toxicity of chemical exposures, the environmental impacts on public health, the management of risks to health and the environment, children's environmental health, and democratic science-based public policy and decision-making.

Richard Denison, Ph.D.
Environmental Defense

Denison serves as a Senior Scientist with the Environmental Defense. With nearly 25 years of experience in the environmental arena, he specializes in chemicals policy, hazard, risk assessment, and management of industrial chemicals, in addition to responsible development of nanotechnology. He has managed Environmental Defense's participation in and oversight of the U.S. High Production Volume Chemical Challenge Program. He also serves on the Chemicals Committee and Working Party on Manufactured Nanomaterials of the Organization for Economic Cooperation and Development (OECD).

Daryl Ditz, Ph.D.
Center for International Environmental Law

Ditz is the Senior Policy Advisor at the Center for International Environmental Law, Chemicals Program, and Coordinator of the National Education Campaign for U.S. Persistent Organic Pollutants Ratification. He has 20 years of U.S. and international experience dealing with environmental health threats through effective public policy and corporate management. Ditz is co-author of "Frontiers of Sustainability, Green Ledgers: Case Studies in Corporate Environmental Accounting," and numerous reports and articles on environmental law, policy and management.

Michael Dourson, Ph.D.
Toxicology Excellence for Risk Assessment (TERA)

Dourson directs the non-profit organization Toxicology Excellence for Risk Assessment (TERA) whose mission is to protect public health. TERA develops partnerships among government, industry and other interest groups to address risk assessments of high visibility chemicals such as perchlorate, chloroform, formaldehyde and soluble nickel. The organization forms cooperative ventures such as the Voluntary Children's Chemical Exposure Program and the International Toxicity Estimates for Risk database. Prior to joining TERA, he worked for the U.S. EPA for 15 years on specific key projects such as the creation of the U.S. EPA's Integrated Risk Information System.

Kenneth Geiser, Ph.D.
Lowell Center for Sustainable Production, University of Massachusetts-Lowell

Geiser serves a Professor of Work Environment and as the Director of the Lowell Center for Sustainable Production at the University of Massachusetts, Lowell. He co-authored the Massachusetts Toxics Use Reduction Act and served as Director of the Massachusetts Toxics Use Reduction Institute from 1990 to 2003. Geiser's research and publications focus on pollution prevention and cleaner production, toxic chemicals management, chemicals policy, safer technologies, and green chemistry. In 2001, Geyser authored "Materials Matter: Towards a Sustainable Materials Policy."

Lynn Goldman, M.D., M.P.H.
Johns Hopkins Bloomberg School of Public Health

Goldman is a Professor at Johns Hopkins University Bloomberg School of Public Health, focusing on environmental health policy, public health, and children's environmental health. She served as Assistant Administrator for the U.S. Environmental Protection Agency's Office of Prevention, Pesticides and Toxic Substances. Prior to that, Goldman served in several positions at the California Department of Health Services, where she conducted public health investigations on pesticides, childhood lead poisoning and other environmental hazards.

John D. Graham, Ph.D.
Pardee RAND Graduate School

Graham serves as Dean of the Pardee RAND Graduate School and Distinguished Chair in Policy Analysis. He is the author or co-author of some 200 books, articles, and reports in the areas of risk estimation and management of health, safety, environment and energy. Graham founded and led the Harvard Center for Risk Analysis from 1990 to 2001. He served as the administrator of the Office of Information and Regulatory Affairs in the Office of Management and Budget and as Professor of Policy and Decision Sciences in the Department of Health Policy and Management, Harvard School of Public Health.

Neil C. Hawkins, Ph.D.
The Dow Chemical Company
Dr. Neil Hawkins currently serves as Vice President, Sustainability for The Dow Chemical Company. In this global role, he is responsible for driving Dow's sustainability performance, including implementation of Dow's landmark 2015 Sustainability Goals, including the transformational Sustainable Chemistry goal. He is also accountable for Product EH&S, Global Regulatory Affairs, Health Services, Remediation, and the regional EH&S implementation organizations. Hawkins has previously held a wide range of Environment, Health & Safety, and Public Affairs roles across Dow. Hawkins joined Dow in 1988, and is in his 20th year with the company. Hawkins holds masters and doctoral degrees from Harvard University, School of Public Health, and a bachelor's degree from Georgia Tech. Hawkins is an expert in environmental risk assessment and environmental policy.

Lauren G. Heine, Ph.D.
Lauren Heine Group LLC, Clean Production Action

Heine's experience and expertise lies in green chemistry, green engineering, sustainable business practices, and multi-stakeholder initiatives. As Principal for the Lauren Heine Group, and a Senior Science Advisor with Clean Production Action, she advises organizations seeking to integrate green chemistry and engineering into product and process design and development activities. Specific areas of expertise include the development of technical tools and strategies for product assessment, evaluation, design and market recognition; and facilitation of multi-stakeholder initiatives. Lauren was previously the Director of Applied Science at GreenBlue where she directed the development of CleanGredients™, a unique, web-based information platform, developed in partnership with the U.S. EPA Design for the Environment Program that promotes green chemistry and environmentally

preferable product formulation by providing information on key human and environmental health, safety and sustainability attributes of cleaning product chemicals.

Vistasp M. Karbhari, Ph.D.
University of California, San Diego

Karbhari is a Professor of Structural Engineering and Professor of Materials Science and Engineering Program at the University of California, San Diego. He leads research groups in such areas as the processing and mechanics of composites, durability of polymers and composites, and bio-materials. He is the author/co-author of over 160 papers in archival journals. He is the American Editor for the International Journal of Materials and Product Technology and is an Editorial Board Member of Composite Structures.

John Peterson Myers, Ph.D.
Environmental Health Sciences

Myers is the founder, CEO, and Chief Scientist of Environmental Health Sciences based in Charlottesville, Virginia. He is also coauthor of "Our Stolen Future," which explores the threats posed by man-made chemical contaminants to fetal development and human health. Myers is Senior Advisor to the United Nations Foundation. From 1990-2002, he was director of the W. Alton Jones Foundation, a private foundation supporting efforts to protect the global environment and to prevent nuclear war. Myers is also senior advisor to Commonweal and to the Jenifer Altman Foundation on environmental threats to children's health.

Mary O'Brien, Ph.D.
Grand Canyon Trust

O'Brien has worked as a staff scientist and organizer for the past 26 years with toxics and conservation organizations, including Northwest Coalition for Alternatives to Pesticides, Environmental Research Foundation, Science and Environmental Health Network, and Hells Canyon Preservation Council. O'Brien taught (1992-1994) as Assistant Professor in the graduate U. of Montana Environmental Studies Program. O'Brien currently works for Grand Canyon Trust for conservation of wildlife habitat and native ecosystems in southern Utah's three national forests. Dr. O'Brien's book, Making Better Environmental Decisions: An Alternative to Risk Assessment (MIT Press 2000), focuses on the power of alternative assessments to leverage positive change.

Barry Trost, Ph.D.
Chemistry Department, Stanford University

Trost serves as a Professor of Chemistry at Stanford University and is the winner of the 1998 Presidential Green Chemistry Award in Academics. He developed the concept of atom economy, which involves reducing the use of nonrenewable resources, minimizing the amount of waste, and reducing the number of steps used to synthesize chemicals. Atom economy is one of the fundamental cornerstones of green chemistry, and is a concept widely used by those who are working to improve the efficiency of chemical reactions.

Michael P. Wilson, Ph.D.
University of California, Berkeley

Michael P. Wilson, PhD, MPH, is a research scientist with the Program in Green Chemistry and Chemicals Policy at the Center for Occupational and Environmental Health (COEH), School of Public Health, University of California, Berkeley. Dr. Wilson conducts research and practice in chemicals policy, green chemistry, exposure assessment, occupational safety and health, and sustainable production. He conducted his doctoral (PhD) and masters (MPH) research in environmental health sciences at the University of California, Berkeley, from 1996 to 2003. He earned a bachelors degree

with thesis honors in biology from the University of California, Santa Cruz, in 1984.

Dr. Wilson is the chief author of a 2006 report to the California Legislature, *Green Chemistry in California: A Framework for Leadership in Chemicals Policy and Innovation* and a lead author of a January 2008 report, *Green Chemistry: Cornerstone to a Sustainable California* for California EPA.

In addition to his appointment to the Green Chemistry Science Advisory Panel, Dr. Wilson was appointed in August by Assembly Speaker Fabian Núñez to the state's Biomonitoring Program Scientific Guidance Panel.

Katy Wolf, Ph.D.
Institute for Research and Technical Assistance

Wolf is Director of the Institute for Research and Technical Assistance (IRTA), a nonprofit organization established in 1989. IRTA conducts pollution prevention research, test and development projects that involve safer alternatives. IRTA identifies, develops, tests and demonstrates alternatives in a variety of applications including cleaning, dry cleaning, electronics, paint stripping, aerospace, coatings and adhesives. A heavy focus of the research is on alternatives to ozone depleting, VOC, toxic and global warming solvents. IRTA runs and operates the Pollution Prevention Center, a loose affiliation of federal, state and local government agencies and a large electric utility. The Pollution Prevention Center members collaborate on projects of mutual interest to find safer alternatives taking into account cross-media and worker exposure implications. Dr. Wolf spent fourteen years at the RAND Corporation where she performed research on alternatives to ozone-depleting substances and chlorinated solvents. She has authored more than 200 publications.

Appendix B: Green Chemistry Initiative Science Advisory Panel Subcommittee Membership

1. **Advancing Green Chemistry Through Evaluation of Data Needs and Availability**	2. **Advancing Green Chemistry and Engineering through Alternatives Assessment**	3. **Advancing Green Chemistry Through Evaluation of Incentives and Barriers**	4. **Advancing Green Chemistry through Education and Information Dissemination**	5. **Science & technology / research challenges & opportunities**
John Balmes	Nicholas Ashford*	Nicholas Ashford	Paul Anastas	Paul Anastas*
William Carroll*	Gail Charnley	Eric Beckman	Eric Beckman	Eric Beckman
Gail Charnley	Richard Denison	William Carroll**	Ken Geiser*	Neil Hawkins
Richard Denison*	Mike Dourson*	Daryl Ditz*	John Graham	Vistasp Karbhari
Lauren Heine	Lauren Heine	Mary O'Brien	Neil Hawkins	Barry Trost
	Mary O'Brien	Mike Wilson	Vistasp Karbhari	
	Katy Wolf	Katy Wolf		
* = co-conveners	* = co-conveners	* = chair ** = vice-chair	* = chair	* = chair
John Warner: floating member	John Warner: floating member	John Warner: floating member	John Warner: floating member	John Warner: floating member

Appendix C: Report of Subcommittee 1 on Advancing Green Chemistry through Evaluation of Data Needs and Availability[44]

Introduction

This report consists of four sections. Section 1 provides an approach to evaluating the needs for data on chemicals, some thoughts on their use in decision-making, and options for developing them. In Section 2 is a case study on selectively generating and evaluating data to support decision making. This case study, related to surfactant properties, is an example of evaluation of existing information, collaborative collection and generation of supplemental information, and the decision-making process in identifying efficacious but less hazardous raw materials. Sections 3 and 4 are listings of databases and sources of information on chemical hazard properties; chemicals uses, releases and exposures; and tools and approaches to data analysis.

Section 1: Green Chemistry Data Needs and Availability[45]

Information is critical to sound decision-making, and chemicals policies are no exception. Indeed, a core function of a chemicals policy should be its ability to facilitate or require the generation of information that can be used to identify and characterize a chemical, understand its manufacturing and use, assess its hazards and exposure potential, and so forth.

In considering the role of information generation in chemicals policies, there are several basic questions:

- What is the importance of having good chemical information?
- What types of decisions are to be informed by the information?
- What types of information may need to be generated?
- What characteristics of the information determine its utility, adequacy, quality, and confidence level?
- What methods can be used to generate the information?
- What options can government use to facilitate or require information generation?
- How can the reliability of information be enhanced?

This chapter will explore each of these issues, highlighting important policy considerations and options.

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[44] Note, the Science Advisory Panel Subcommittee reports are products of the Subcommittee that authored the report , not the entire Panel.

[45] This discussion is adapted and abridged from Denison, R.A. (2008) "Policy Options for Generating Information for Sound Chemicals Management," in *Options for State Chemicals Policy Reform: A Resource Guide*, Lowell Center for Sustainable Production, University of Massachusetts at Lowell, January 2008, pp. 35-68, available at www.chemicalspolicy.org/downloads/OptionsforStateChemicalsPolicyReform.pdf.

Why Information on Chemical Hazard, Use, and Exposure Is Important

Having at least basic, reliable, and current information on how chemicals are produced and used as well as their potential hazards and exposures can help to identify and prioritize chemicals of concern for further assessment and risk reduction and management efforts. Equally important, generating a broad base of information about most if not all chemicals in commerce aids in identifying not only chemicals of concern, but also chemicals that pose little or no risk and hence may serve as potential alternatives or replacements for the riskier ones.

It is important to clearly and explicitly characterize the extent of information available on chemicals. In this regard, attention should be drawn to **data gaps** as well as available data on chemicals. Knowing what information is **not** available about a chemical can be important to assessing the level of confidence that can or should be placed in decisions concerning that chemical. And prominently identifying missing data can provide incentives to develop more and better data.

Finally, independent of the extent to which government itself acts on chemical information to identify and reduce or manage risks, the generation of such information – coupled with providing broad access to it – can empower a host of other actors to make better decisions about the chemicals they produce, use, sell, or purchase. Access to such information may well drive market demands for more information and migration away from chemicals known or suspected of being risky, even without direct government intervention.

While there is legitimate debate over how much information about chemicals is needed, there is growing recognition that current federal policy constrains government's ability both to generate and to provide access to chemical information.[46] Some of the major existing sources of information on chemicals' hazards, uses and exposures – and the limitations to this information – are described in Section 3.

Types of Decisions for Which Information Is Needed

Decisions clearly need to be informed by information, but how much is needed? What and how much information is needed depends in no small part on what type of decision is being made. A range of types of decisions requiring chemical information can be envisioned, for example:

- Review of chemicals prior or subsequent to their manufacture or use;

[46] For a more in-depth discussion of U.S. chemicals policy under the Toxic Substances Control Act (TSCA) and how it compares to that of the European Union (under its new REACH Regulation) and Canada under the Canadian Environmental Protection Act (CEPA), see Denison, R.A. (2007) *Not That Innocent: A Comparative Analysis of Canadian, European Union and United States Policies on Industrial Chemicals* (Environmental Defense Fund, Washington, DC), at www.environmentaldefense.org/go/chempolicyreport.

- Initial screening or prioritization of chemicals for further scrutiny or action;
- Determination of additional information needs;
- Assessment of a chemical's hazard, exposure, or risk;
- Chemical design and product development;
- Selecting among alternatives for a given use or function;
- Determination of needed controls by government or industry;
- Development of regulations; or
- Development of purchasing policies or criteria.

While there is no magic formula to determine information needs for a given decision, some general principles can be articulated:

- Some decisions require less or less certain information than others. Screening decisions – where a relatively high capture rate of "false positives" can be tolerated in exchange for minimizing the exclusion of "false negatives" – can sometimes be made using fewer data since initial capture decisions will typically be revisited and potentially revised using more and better information.
- Some decisions require only certain types of information. A decision to identify a chemical as sufficiently hazardous as to require the development of better exposure information – for example, to list a chemical on the TRI and require reporting of information on environmental releases – does require good hazard information but should not hinge on significant evidence of exposure (and hence risk), since the very purpose of the decision is to develop such information.
- Decisions being made at design or pre-commercial stages of a chemical's life – such as a company deciding whether to proceed with product development or which among several alternative substances to choose, or government deciding whether to allow manufacture to commence – may warrant, or may of necessity only be possible to be informed by, less information than decisions that affect more established chemicals.
- Decisions to collect or generate certain types of information may be triggered by what previously collected information reveals: For example, detection of a chemical in a biomonitoring program could lead to a decision to require more extensive testing for hazardous properties, or, conversely, evidence of hazard to humans or environmental persistence could trigger a requirement to conduct biomonitoring for a chemical.

In general, decisions of a more tentative nature or those made at an early stage in a process (be it in the course of product development or development of a regulation), and hence are likely to be revisited or reconsidered, may tolerate less information, while more definitive and impactful decisions demand more. Of course, mechanisms are needed to ensure that both the development and reconsideration of better information actually take place as the degree of confidence needed in a decision increases.

Types of Information that May Be Needed

Broadly speaking, several major types of information are typically needed to inform sound decisions concerning safe management of chemicals. They include:

- Information on a chemical's inherent characteristics:
  - identity, composition, properties, physical form, and so forth.
  - environmental fate and transport in various environmental media, including its persistence and susceptibility to degradation.
  - biological fate and behavior, including its extent of adsorption into an organism, its movement and distribution within; its biopersistence and potential to accumulate or be metabolized, and so forth.
  - toxicity to living organisms.
- Information on production, handling, function/use, and lifecycle management:
- Information on concerning potential and actual releases and exposures:
  - to workers, consumers, the public (or subpopulations) or the environment;
  - presence in the environment and organisms, including humans.

Important Information Characteristics

Many other characteristics of the information will determine if, when, and where it is needed, useful, and appropriate to be used for a given decision. To be of use, the information must be sufficiently **reliable** (for example, current, accurate, viewed as credible) and **timely** (that is, collected or generated and made available at the right time to inform a decision).

The **quality** of and degree of confidence that can be placed in chemical information are important considerations, and need to be characterized and communicated as explicitly as possible. It is also critical to ensure that any resulting limitations with regard to appropriate and inappropriate uses of the information are understood and communicated. Measures and dimensions of quality[47] can include:

- Representativeness;
- Extent of adherence to established methods, including good laboratory practice;
- Extent of validation of methods, models, and results;
- Extent of documentation provided, including access to underlying raw data;
- Extent to which results have been replicated or independently verified;
- Extent to which data are empirically measured vs. estimated or modeled

[47] For a fuller discussion of data quality issues, including for data generated by industry and through the use of alternatives methods, see Appendix A of Denison, 2008, *op. cit.*

- Extent of reliance on expert judgment assumptions;
- Characterization and communication of the associated confidence level;
- Publication, peer review.

As noted earlier, the extent to which data are **complete** – or alternatively, the extent of data gaps – can also be an important measure of data quality. Being able to identify such gaps requires, of course, an accepted benchmark for what constitutes sufficient or "complete" data – which can in turn depend on the purpose and use of the data. Minimum data sets have been developed and used in a number of regulatory and voluntary programs.[48] Perhaps equally needed but as yet not well developed would be an articulation of the desired amount of information that should be available for all chemicals, or for chemicals used in particular ways (for example, present in consumer products). Such data sets could serve effectively as both yardsticks and goals for measuring progress in closing the gap between what we know and what we should know about the chemicals we make and use.

Methods Available to Generate Information

Information on hazard and exposure can be developed by a variety of means:

- Empirically through measurement or testing, for example,
  - Through epidemiological studies or biomonitoring,
  - Using *in vivo* or *in vitro* toxicity test methods, or
  - Through sampling and analysis, e.g. of environmental media (air, water).
- By estimation through models or interpolation/extrapolation, for example,
  - Using a quantitative structure-activity relationship (QSAR) model to estimate toxicity,[49]
  - Using "read across" from structurally related chemicals,[50] or

[48] Examples include new chemical notification regulatory requirements in Canada and the Organization for Economic Co-operation and Development's (OECD) Screening Information Date Set (SIDS) used in the voluntary HPV Challenge.

[49] A QSAR is a mathematical model that yields a quantitative estimate for a specific toxicological endpoint or other biological property for an untested chemical. QSARs are developed using a body of empirical data (termed a "training set") derived from analyzing or testing multiple chemicals for both a) physical-chemical properties that correlate to specific structural features, and b) toxicological endpoints or other biological properties of interest. The quantitative relationship between these two sets of properties for the tested chemicals is then expressed in the form of an algorithm. The algorithm can in turn be used to estimate values for toxicological or other biological properties of an untested chemical, based on the extent of similarity in its chemical structure and/or physical-chemical properties relative to those chemicals in the training set.

[50] "Read-across" (often also known as qualitative SAR) refers to methods in which values for an untested chemical are derived from tested chemicals, based on the extent of structural or functional similarity. The read across method is usually applied in either of two ways:

- Within a category of structurally and/or functionally related chemicals, only some of which have been tested. An example of such a category is a group of fatty acids that differ only in the length of an attached

    - Using an exposure model to estimate release or exposure.
- Exercising expert and experience-based judgment, for example, by
    - Applying weight-of-evidence (WOE) approaches to resolve conflicting information or combine pieces of information, none of which alone would be deemed sufficiently reliable but which together support a conclusion, or
    - Using assumptions deemed reasonable in the absence of hard information.[51]

Data generated using these different methods possess inherent differences that in turn affect their expected reliability and associated confidence level and hence delimit their appropriate use. This factor reinforces the need to align the degree of confidence needed for the decision being made to the degree of confidence that can be expected from the methods being used to generate information.

Hazard information:[52] Hazard data derived using alternatives to traditional chemical testing have been used or are allowed to be used to meet data requirements in both voluntary programs[53] and many regulatory programs.[54] They also have been used by government authorities to

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carbon chain (e.g., C2, C4, C6, etc.). If, for a given endpoint, empirical values are available for the C2 and C6 category members but not for the C4 member, reading across can be done across these three chemicals to estimate that the value for C4 falls between the values for C2 and C6.

- Used to provide an endpoint value for an untested chemical by simply adopting the value for a tested "analog" (also known as a "surrogate") chemical considered to be sufficiently closely related to it.

In both cases, testing-derived data for some chemicals are used to extrapolate, estimate or provide data for "related" chemicals that have not been directly tested.

[51] While expert judgment and the use of assumptions are not strictly to be viewed as sources of actual information, they effectively act as such and represent means of compensating for the lack of "hard" information. And they are widely used in practice where other information is not available, is considered too time-consuming, difficult or expensive to develop, etc. "Reasonable worst-case assumptions," for example, are frequently used by government in assessing chemicals for which few data are available.

[52] For a fuller discussion of principles that need to be applied to the use of alternative methods to traditional chemical testing, and a discussion of specific limitations of each method or approach, see Denison, R.A. and Balbus, J.M. "Environmental Defense Perspective on Integrated Approaches to Chemical Testing and Assessment," presented at the 39th Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides and Biotechnology, Organization for Economic Cooperation and Development, 15-17 February 2006, available at www.oecd.org/dataoecd/19/34/36286018.pdf.

[53] See EPA's guidance documents for the U.S. High Production Volume (HPV) Chemical Challenge, at www.epa.gov/chemrtk/pubs/general/guidocs.htm; and OECD's *Manual for Investigation of HPV Chemicals* for its SIDS Program, at www.oecd.org/document/7/0,2340,en_2649_34379_1947463_1_1_1_1,00.html.

[54] See Canada's New Substances Notification Regulations, *Guidelines for the Notification and Testing of New Substances: Chemicals and Polymers*, Pursuant to Section 69 of the *Canadian Environmental Protection Act, 1999*. Co-published by Environment Canada and Health Canada. Version 2005 – EPS M-688, Section 8, at www.ec.gc.ca/substances/nsb/pdf/cpguidem688.pdf; and the European Union's REACH Regulation, Annex XI, p. 371, at eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_396/l_39620061230en00010849.pdf. REACH stands for Registration, Evaluation, Authorization and Restriction of Chemicals.

screen or prioritize chemicals for further scrutiny or management. For example:

- U.S. EPA's New Chemicals Program has developed and made extensive use of QSARs and category read-across approaches to predict the hazards of chemicals it reviews that lack actual test data.[55]
- Under Canada's recently completed Domestic Substances List (DSL) Categorization process, Health Canada used many different types of data, assigning confidence levels to different data sources.[56]
- The State of Washington recently commissioned an assessment of alternatives to the flame retardant decabromodiphenyl ether (deca-BDE) that used QSAR model estimates to supplement the test data available to characterize the relative hazards of deca-BDE and the alternatives. The models employed were the same as those used by U.S. EPA's New Chemicals Program.[57]

Interest in promoting alternatives is motivated by a desire to: gain efficiencies in assessing new chemicals prior to market introduction as well as in addressing the huge backlog of un- or under-assessed chemicals already on the market; reduce the costs associated with traditional testing; and reduce unnecessary use of laboratory animals. They are all worthy objectives. At the same time, it is critical that an appropriate balance be struck with other equally important objectives: assuring full protection of human health and the environment; basing decisions on scientifically sound and defensible information; ensuring that all assessment information used to make such decisions is independently verifiable and reproducible; and maximizing transparency in communicating the basis for decisions to stakeholders and the general public.

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[55] U.S. Environmental Protection Agency, *Overview: Office of Pollution Prevention and Toxics Programs*, January 2007, prepared by OPPT ("OPPT Overview, 2007"), pp. 7-8, at www.epa.gov/oppt/pubs/oppt101c2.pdf.

[56] In order of highest to lowest confidence, the sources included: 1) acceptable assessments of international or national agencies and secondary reviews; 2) original study accounts of empirical tests; 3) predictions of QSAR models, information on chemical substructures of concern, and analogue or surrogate chemicals. See Health Canada, *Proposed Integrated Framework for the Health-related Components of Categorization of the Domestic Substances List under CEPA 1999*, June 2005, Part C, p. 24, at www.hc-sc.gc.ca/ewh-semt/contaminants/existsub/categor/publi-comment/index_e.html.

[57] Syracuse Research Corporation, "Flame Retardant Alternatives," study conducted for the Washington State Departments of Ecology and Health, February 2006, available at www.ecy.wa.gov/programs/eap/pbt/pbde/docs/flameRetard.pdf.

Exposure Information:[58] Three uses of information about chemical exposures are prevalent in existing practice. It is used directly, in combination with hazard information, to assess the risks posed by a chemical, typically under the rubric of risk assessment. It is used to identify chemicals to which there is significant exposure as a means to prioritize among chemicals and target them for further assessment or control. Third, and more controversial, exposure information can be used to "moderate" the extent of hazard testing required to be conducted or, for a chemical already identified to be hazardous, the priority given to further assessment or risk management.[59]

While both hazard and exposure are clearly relevant in determining chemical risks, there are critical differences between our ability to assess hazard and exposure:

- Hazard is largely inherent to a substance, while exposure changes with place, use, and time. Exposure assessment must therefore characterize variation in as well as magnitude of exposure.
- Mechanisms for generating and evaluating hazard data are far more advanced and accepted than for exposure data. While extensive international-consensus standards exist for generating hazard data, standardized and routine collection of exposure data is rare and infrequent, and public access to them even rarer.
- Differential access to both exposure data and the means to generate them can severely limit the "reproducibility" of such data. Most exposure data and the means to generate them (e.g., by gaining access to exposure "settings" such as workplaces) reside largely with industry. Having the ability to independently verify such information is therefore essential.
- Confidential business information (CBI) restrictions limit public access to much exposure data; in contrast, hazard data are typically ineligible for CBI protection.

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[58] For a fuller discussion of the limitations of exposure information and their policy implications, see Denison, R.A. "Environmental Defense's perspective on policy issues related to exposure assessment," in *OECD Series On Testing And Assessment, No. 51, Approaches to Exposure Assessment in OECD Member Countries: Report from the Policy Dialogue on Exposure Assessment in June 2005*, Chemicals Committee, Organization for Economic Cooperation and Development, p. 109, available at http://appli1.oecd.org/olis/2006doc.nsf/linkto/ENV-JM-MONO(2006)5.

[59] An example of the former is REACH, under which "substance-tailored exposure-driven testing" is available for tests involved the use of laboratory animals; the waiver is available to any registrant that can demonstrate that exposure to a chemical is low. See REACH, *op. cit.,* Article 13(1) and Annex XI, Section 3. An example of the latter is the OECD SIDS Program, under which even a hazardous chemical can be deemed a "low priority for further work," based on consideration of minimal information that suggests exposure is "anticipated to be low." See Denison, R.A. "Environmental Defense's perspective on policy issues related to exposure assessment," in *OECD Series On Testing And Assessment, No. 51, Approaches to Exposure Assessment in OECD Member Countries: Report from the Policy Dialogue on Exposure Assessment in June 2005*, Chemicals Committee, Organization for Economic Cooperation and Development, p. 109, at appli1.oecd.org/olis/2006doc.nsf/linkto/ENV-JM-MONO(2006)5.

- Finally, supply-chain impediments to sharing exposure-relevant information abound, where for competitive reasons both suppliers and their customers have only limited access to information in the possession of the other party.

These limitations need to be carefully considered in the development, use and communication of exposure information, especially in a public policy context. Even where exposure information is relatively reliable and complete, there is still the need to develop hazard information for a chemical, which has value independent of exposure and will virtually inevitably be needed as the exposure situation changes.

Government's Options for Generating Information

Sometimes chemical information already exists and can simply be collected and compiled, while in other cases it must be generated *de novo*. Some chemical information may be largely in the possession of those companies that produce and use the chemical, while some may be independently accessible or able to be developed. Finally, such information may be published or otherwise publicly available, or it may be unpublished or publicly inaccessible (for example, confidential business information).

Government has several basic options when it comes to facilitating the reporting or generation of chemical information. It can:

- Itself collect or generate the information;
- Require commercial producers or users of chemicals to report existing or generate new information;
- Request that information be provided voluntarily or provide incentives for companies to do so;
- Help to develop and shape a market in which the collection or generation of the information has economic value.

Each option is discussed below, along with advantages and disadvantages of each.

1. Government can itself collect or generate the information.

This activity can be undertaken through research agencies, government laboratories or in some cases by regulatory agencies. Examples of federal government-developed chemical information include toxicological testing conducted by the National Toxicology Program, biomonitoring of human blood and urine conducted by the Centers for Disease Control, and workplace inspections and air sampling conducted by the Occupational Safety and Health Administration.

Advantages of direct government generation of information include the following:

- The information will be associated with a relatively high degree of public trust.
- Government has direct control over the methods used, the documentation provided, and other factors important to developing reliable data in a transparent and accountable manner.
- Government and the public have full access to the results and underlying data.

Among the disadvantages or limitations are the following:

- Government bears the cost of generating the information.
- For government to generate data on large number of chemicals could exceed available financial and human resources, including laboratory capacity.
- For new chemicals just being developed or yet to be commercialized, it is more difficult to see how government could intervene.
- Government conducting all testing could effectively undermine incentives for companies to maintain and enhance their expertise and capacity to consider risk in chemical design, that is, green chemistry, pollution prevention approaches.

2. Government can require commercial producers or users of chemicals to report existing or generate new information.

Government imposition of requirements for industry to report existing information or generate new information is probably the most common approach used by government to develop chemical information. This approach is used across all major types of chemicals, including pesticides, pharmaceuticals, and industrial chemicals. Testing requirements are most commonly imposed at the time of a chemical's first introduction. Examples of this approach include the registration of pesticides under the U.S. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); reporting and test rules and inventory update reporting requirements for existing chemicals under TSCA;[60] and the reporting, testing, assessment, and risk management requirements under the Registration provisions of the European Union's REACH Regulation.

[60] Under TSCA, full notice-and-comment rulemaking is usually required to impose reporting or testing requirements. Testing rules – in contrast to rules requiring the reporting of already existing information – require that government makes certain findings that a chemical poses significant potential risk or high exposure. EPA has indicated that a rule can take between 2 – 10 years to promulgate and requires significant resources. See Government Accountability Office, Report GAO-05-458, *Chemical Regulation—Options Exist to Improve EPA's Ability to Assess Health Risks and Manage Its Chemical Review Program*, 2005, p. 26, at www.gao.gov/new.items/d061032t.pdf. In the 30 years since TSCA was enacted, EPA has required testing for fewer than 200 chemicals. Where EPA determines that additional data are needed to assess a new chemical, rather than promulgate a regulation, it typically negotiates with notifiers an agreement to conduct testing, which is known as a Voluntary Testing Action; about 300 such actions have been developed. See EPA, OPPT Overview, 2007, *op. cit.*, p. 11.

Advantages of government compelling industry to report or generate information include the following:

- It places the burden of information development on the producers and users of chemicals, not government.
- Information can potentially be developed on many more chemicals than government would be able to generate by itself.
- Industry potentially has an incentive to develop and use safer chemicals, in order to avoid having to report information indicating potential hazard or risk and be required to take action to mitigate risk.

Disadvantages and limitations include the following:

- Industry has an incentive to downplay hazards or risks of its chemicals, which has the potential to compromise the reliability of the information it generates.
- Selective reporting is a concern, although requirements typically exist that compel industry to submit any information indicative of significant risk.
- Under TSCA, government must generally demonstrate that an existing chemical may pose a significant risk or has widespread exposure to compel any testing[61]
- Government resources required to review industry data for quality, accuracy and completeness are still substantial.
- Public trust in information from industry is typically lower than for government.

3. Government can request that information be provide voluntarily or provide incentives for companies to do so.

The most prominent example in the U.S. of this approach is the HPV Challenge. Another example where U.S. EPA has encouraged and provided an incentive to industry to develop and submit information is the Sustainable Futures Initiative, under which companies are trained and encouraged to employ the same suite of predictive tools U.S. EPA uses to assess new chemicals[62]

Advantages, in addition to those listed above for regulatory approaches, of voluntary efforts through which industry reports or generates information include the following:

- They bypass statutory findings regarding risk that must be made in some jurisdictions to compel testing.
- They can often be implemented more quickly than can regulations.
- They are less likely to be contested by industry than regulations.

Disadvantages and limitations, in addition to those listed above for regulatory approaches, include the following:

[61] TSCA, Section 4; and CEPA, Sections 71 and 72.

[62] See www.epa.gov/oppt/newchems/pubs/sustainablefutures.htm.

- Government has little recourse if data quality is poor, data are incomplete, deadlines are not met, or agreed procedures are not followed, since there is no legally binding obligation imposed on companies.
- The extent of participation is difficult to predict.
- The ultimate incentive for companies to participate is likely the extent to which government can compel testing if extent of voluntary participation is deemed insufficient; hence, the very limitations and constraints government faces in seeking to develop regulations may also significantly influence the extent and quality of voluntary participation.

4. Government can help to develop and shape a market in which the collection or generation of the information has economic value.

Government's provision of broad public access to chemical information it acquires by whatever means can itself significantly affect market dynamics and other economic dimensions of decision-making about chemicals.[63] In this context, the "public" includes end consumers; governmental and non-governmental institutions (for example, hospitals), companies that purchase chemical products; and companies that make or sell such products. Access to chemical information may well drive market demands for more information and migration away from chemicals known or suspected of being risky, even without direct government intervention.

Registration requirements for pesticides under FIFRA and the EU's REACH Regulation establish that companies must demonstrate that they have rights to the information they submit to meet information requirements. If they did not themselves generate the information, they are generally required to compensate the owner of the information to gain the right to use it – thereby imparting monetary value to the information.

California's Proposition 65 requires companies that make products containing any chemical "known to the state of California" to be a carcinogen or reproductive toxicant to label the product – unless the chemical is present below an agreed-upon *de minimus* level. In addition to shifting the burden of proof of safety to companies, Proposition 65 arguably economically rewards companies that generate information about a chemical that allows a no-effect level to be set, because they can avoid negative labeling.

Government procurement policies toward products that contain or are made from chemicals can influence the value assigned to chemical information. As large

[63] A field of specialization within economics known as information economics has demonstrated that access to information is a critical need if markets are to operate properly, and, conversely, that the lack of robust information can adversely affect market economies. See, e.g., papers by J.E. Stiglitz cited in Guth, J., Denison, R.A. and Sass, J. (2006) "Background Paper #5, Require Comprehensive Safety Data for All Chemicals," at www.louisvillecharter.org/paper.safetydata.shtml.

purchasers of products and services, governments represent a significant increment of market demand. Development and communication of clear criteria that will govern governments' purchase of products and services involving chemicals can help drive markets toward production and use of safer and better characterized chemicals[64]

Advantages of such approaches include the following:

- They work through, and hence are more likely to be aligned with rather than work against, market incentives and dynamics.
- They do not require direct government intervention to restrict use of a chemical.
- They potentially empower a much broader array of actors to make informed decisions about chemicals.

Among their limitations:

- It is difficult to predict the nature and extent or ensure the effectiveness of and track actions taken by entities outside government to reduce chemical risks.
- If market dynamics are not working satisfactorily, there is no direct means to compel or increase compliance.

Relevance to State-Level Policy-Making

States have a critical role to play in chemicals policy development and implementation, not only in affecting practice within their borders, but also in innovating new policy approaches and driving national policy forward. The information generation options discussed in this section differ, however, in the extent to which they can or should be pursued or implemented at a national versus state government level, as well as the extent to which any individual state has the capacity or authority to actually do so. A few examples of criteria or considerations that could be used to distinguish among the options with respect to state-national differences are provided here, but are not meant to be prescriptive or limit what options a state government may wish to pursue.

As discussed earlier, because information about a chemical's use and human or environmental exposure to it is often specific to a geographic region and may change over time, such information may be appropriately developed at the state level. States can and should take steps to understand which chemicals are produced in or imported into their states, as well as how they are transported, stored, processed, and used. Data on chemical releases and exposures within a state (for example, emissions information, concentrations in a state's environmental media or food supply, biomonitoring of state residents and wildlife, including unique or especially susceptible subpopulations) can provide important

[64] See, for example, EPA's Environmentally Preferable Purchasing (EPP) website at http://www.epa.gov/epp/pubs/about/about.htm.

geospatial information and be essential to setting a state's priorities for action. Of course, the development and maintenance of databases of chemical information can be expensive and may entail specialized expertise. Coordination among states in developing and sharing such information may prove useful in extending expertise and resources and in avoiding duplication.

States can have particular policy priorities, which may arise from many different sources; they may, for example, have cultural or historic origins, signify economic conditions, or reflect geospatial distinctions, such as the extent of reliance on groundwater or features of the natural landscape (for instance, major watersheds).

Some states have decided to focus on particular classes or uses of chemicals of concern. Washington, for example, has established as a priority the identification and restriction of PBT chemicals, with an initial focus on mercury and brominated flame retardants.[65] As one response to the contamination of fish – a key state resource – with mercury, Maine has adopted a product focus, prioritizing the identification and elimination of mercury-containing products[66] While different states will pursue different approaches, they can and should be communicating and coordinating their activities as much as possible, in order to learn from each others' experiences, share information, avoid duplication and exploit synergies and economies of scale.

Conclusion

The development of good information about chemicals underpins all other aspects of chemicals policy: Information is critical to the evaluation and prioritization of chemicals, to consideration of alternatives to chemicals of concern, and to research and innovation with respect to green chemistry, and to overall program administration and implementation. The development of more and better information will allow us not only to identify which chemicals pose risks, but also which ones pose little or no risk and could replace riskier ones. Indeed, one potentially enormous, but largely unsung, benefit of adopting a comprehensive approach that seeks to develop risk profiles for most or all chemicals would be the ability to select safer chemicals with confidence.

This section has explored the basic questions of what, how, by whom, for whom, and why chemical information is to be generated. In general, the section argues for taking a broad approach with respect to both the extent of information that should be developed and the range of actors and the ways by which that information can be used. Better information, coupled with greater access to it, will empower a range of others besides government to act to control chemical risks.

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[65] See Department of Ecology website, www.ecy.wa.gov/programs/eap/pbt/pbtfaq.html.

[66] See Department of Environmental Protection website at www.maine.gov/dep/mercury/products.htm.

This includes companies that purchase and use chemicals in their products, retailers that sell chemical products, businesses and institutions (for example, hospitals, hotel chains) that buy chemical products, as well as workers, consumers, public interest groups, government and academic researchers, and the broader public.

Section 2. A Case Study on Selectively Generating and Evaluating Data to Support Chemical Decision-Making

Chemical data needs and data quality requirements can depend in part on how a chemical is used. It is possible in some cases to identify a limited set of data needs that will support decision making. For example, the U.S. EPA's Design for the Environment (DfE) Formulator Partnership Program identifies cleaning products that are best in their class with respect to human health and environmental fate and toxicity (environmental preferability)[67] Products that qualify are allowed to carry the DfE logo – a source of positive recognition the marketplace. DfE has reviewed hundreds of cleaning product formulations, and evaluates ingredients within categories based on chemical class (i.e., solvents, surfactants, fragrances, etc.) and functional use (i.e. cleaning).

DfE identifies both characteristics of concern and preferred or "sustainable" characteristics of ingredients based on their functional use. The Formulator Program was initially offered at no cost to product formulators and once word got out, interest increased rapidly beyond the capacity of the small DfE Program. In response, DfE did two things. While maintaining oversight of qualification for the logo (still at no cost for qualifying products), DfE outsourced the ingredient and product profiling to a 3rd party, which provides the service for a fee (currently NSF International). It also funded the CleanGredients™ project to address formulator requests for help identifying "greener" raw materials. CleanGredients™ is an online platform that helps:

- Manufacturers of cleaning product ingredients to showcase their chemicals with environmentally preferable human and environmental health attributes, and
- Cleaning product formulators to identify ingredients for use in their environmentally preferable products[68]

The CleanGredients™ platform is both a benchmarking tool and an information resource. Typically, ingredients must meet one set of criteria to be listed in CleanGredients™ and a more stringent set of criteria to meet the DfE Screen. Ingredients that meet the DfE screen are recommended for use in products for

[67] http://www.epa.gov/dfe/pubs/projects/formulat/index.htm

[68] http://www.cleangredients.org

which the manufacturer sees DfE recognition. The CleanGredients™ criteria are defined by multi-stakeholder Technical Advisory Committees (TACs) composed of raw material suppliers, product formulators, and individuals from government and NGOs. DfE participates in all of the TAC meetings, and also defines the DfE Screen criteria – the higher bar – for each ingredient class. While the DfE Screen criteria are determined by DfE, they are designed to harmonize with attributes and criteria developed by the TAC.

The point of the DfE Screen is to define the key attributes and criteria for use in discriminating between chemical raw materials by chemical class or functional use, i.e., comparing solvents to solvents and chelating agents to chelating agents, in order to identify those within a category with the most preferable characteristics for use in cleaning products.

The TAC first defined information requirements and divided them into tiers. Tier I attributes require certain test data and third party review. Tier I attributes for surfactants include rapid and complete biodegradability and aquatic toxicity. Data may be drawn from the literature and read-across data may be used where appropriate. However for biodegradability, it was determined that read-across data often did not adequately consider the extent of branching, which affects the rate of biodegradation. Data on Tier 2 attributes for surfactants are to be submitted if known but do not require new testing or third party review. Tier 3 attributes, submission of which is entirely voluntary, include such information as whether or not there is a lifecycle assessment for the chemical and whether or not it is bio-based. The set of attributes selected for inclusion in CleanGredients and in the DfE Screen are as follows:

Tier 1 Surfactant Attributes
Acute Aquatic Toxicity (Fish, Daphnia, Algae)
Biodegradability
Consideration of degradation products

Tier 2 Surfactant Attributes
Sensitization
Irritancy
Acute Mammalian Toxicity (Oral, Dermal)
VOC Content
Presence of alkyl phenol ethoxylates (APEs)

Tier 3 Surfactant Attributes
Life Cycle Assessments
Risk Assessments
Endocrine Disruption test data
Additional Aquatic Toxicity (Microtox, Chronic)
Other Product Features
Origin of Feedstock

The CleanGredients™ platform presents both validated (Tier I) and non-validated (Tier II) test data, identifies whether or not an ingredient meets the DfE Screen, and provides a platform for presenting ingredient information that is relevant to green product formulation. The approach is notable for using a collaborative multi-stakeholder process to develop its attributes and criteria. It facilitates more efficient communication between raw material suppliers and product formulators and leverages market forces by linking to product recognition by DfE. Costs of product review are decreased because already reviewed ingredients are publicly listed with validated information on key attributes and hence there is no need for additional testing or ingredient review.

The DfE approach is effective because it clearly defines a set of desirable attributes and criteria and the associated data needs for ingredients based on chemical class and functional use. A specific DfE Screen is developed for each class of ingredients. For example, for solvents, there is a strong focus on human health endpoints, with the specific data needs varying with the chemical class, e.g., alcohols, ethers, esters, etc. In contrast, for surfactants, the key attributes focus on environmental fate and toxicity. With key attributes and criteria to be considered in the review designated up front, raw material suppliers can prioritize data needs and avoid unnecessary costs associated with testing and validation for non-key test endpoints. This in turn helps product formulators who need the data for green product formulation. The program is also based on continual improvement, so that as more and more ingredients are successfully developed to meet the DfE Screen criteria, additional requirements may be set – raising the bar and helping to drive further development of greener chemicals.

Section 3: Some Current Sources of Chemical Hazard, Use and Exposure Information, and their Limitations

Data on Industrial Chemical Hazards: Current U.S. policy toward industrial chemicals,[69] embodied in the Toxic Substances Control Act of 1976 (TSCA), creates a number of significant barriers to the development of better information about chemical hazards. First, U.S. EPA is required under TSCA to review new chemicals prior to their manufacture. However – unlike virtually all other developed countries – TSCA does not require (or allow U.S. EPA to require) a minimum base set of data on a chemical's environmental fate and behavior,

[69] Industrial chemicals, regulated under TSCA, typically exclude chemicals used only as pharmaceuticals, cosmetic ingredients, pesticides or food additives, which are regulated under other statutes. The term is not intended to mean that such chemicals are used only in industry; many "industrial chemicals" are also present in consumer products. Except where otherwise noted, this section's use of the term "chemical" will typically refer to industrial chemicals.

toxicity or ecotoxicity. Although U.S. EPA encourages such data to be included in the PMN, the great majority of PMNs do not[70]

Second, government's ability to compel the generation of hazard information for chemicals already in commerce is also constrained: to require a company to test a chemical, U.S. EPA faces a classic Catch-22: it must already have substantial evidence of potential risk or high exposure to direct a company to develop information needed to determine whether there is actual risk[71] These burdens are sufficiently high that, in the 30 years since TSCA was enacted, U.S. EPA has required testing for fewer than 200 chemicals[72]

The magnitude of the hazard data gap for industrial chemicals was illuminated in a 1998 U.S. EPA report that found that 43 percent of the roughly 3,000 chemicals produced in annual quantities of one million pounds or more (so-called high production volume, or HPV, chemicals) had no publicly available screening-level hazard data, and only seven percent had a complete screening-level base set when measured against an internationally agreed minimum data set[73]

These circumstances – large data gaps and limited regulatory authority – led U.S. EPA to launch the U.S. High Production Volume (HPV) Chemicals Challenge in 1998,[74] which enlists producers of HPV chemicals to voluntarily develop and make publicly available a "base set" of screening-level hazard

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[70] According to EPA: 67% of PMNs contain no test data; 85% of PMNs contain no health data; and more than 95% of PMNs contain no ecotoxicity data.

The first two statistics are from U.S. Environmental Protection Agency, *Overview: Office of Pollution Prevention and Toxics Programs*, January 2007, prepared by OPPT ("OPPT Overview, 2007"), p. 8, at www.epa.gov/oppt/pubs/oppt101c2.pdf. The third statistic is from EPA, OPPT, *Draft Q&A for the New Chemicals Program*, undated, answer to Question 118-5, at www.epa.gov/opptintr/newchems/pubs/qanda-newchems.pdf.

[71] EPA must also affirmatively demonstrate that insufficient data exist and that testing is needed to provide the data. To make the requisite findings, EPA often must first issue information reporting regulations under §§8(a) and 8(d) to determine whether sufficient data exist, whether substantial production is occurring and whether significant exposure is likely. To develop and issue such rules can take several years or more and place significant strain on limited EPA resources.

[72] EPA, OPPT Overview, 2007, *op. cit.*, p. 4.

[73] EPA's 1998 Data Availability Study is at www.epa.gov/chemrtk/pubs/general/hazchem.htm. The undertaking of that study and the launch of the HPV Challenge were spurred by a 1997 report, *Toxic Ignorance*, published by Environmental Defense Fund, which examined 100 HPV chemicals and found that more than 70% of them lacked publicly available data sufficient to conduct even a screening-level hazard assessment. *Toxic Ignorance* and other Environmental Defense Fund reports and information on the HPV Challenge is at www.environmentaldefense.org/subissue.cfm?subissue=14. The benchmark used to measure how "complete" available data are is the OECD's SIDS – see endnote 12.

[74] See EPA's HPV Challenge web site, at www.epa.gov/chemrtk/index.htm.

information[75] on their chemicals. The HPV Challenge is the only systematic effort by U.S. EPA to call for basic hazard data on a relatively large number of existing chemicals. Because it is voluntary, it also sidesteps the regulatory findings U.S. EPA must make to compel data development. However, for the same reason, U.S. EPA also has had limited recourse to ensure full participation by manufacturers or the timely submission and high quality of hazard data sets developed for HPV chemicals[76]

Limitations to Data on Chemical Uses and Exposures: While the federal government does have a number of programs to collect information related to chemical uses, releases, and exposures, each has a number of significant limitations that preclude such programs from providing a comprehensive set of information to inform policy and regulation. This section describes several examples of current programs along with their limitations.

Reporting of chemical use information: For chemicals already in commerce, U.S. EPA requires reporting of limited information on how chemicals are used and the extent to which environmental releases or exposures to workers, consumers, or the environment may occur, and it does so infrequently. Under TSCA, such reporting can be required only of chemical manufacturers (and in some cases, processors), but not of companies that use chemicals, whether directly or as ingredients in products.

Routine but limited reporting of use and exposure information by manufacturers has just been initiated under U.S. EPA's Inventory Update Rule (IUR)[77] Beginning in the 2006 reporting cycle, "known or reasonably ascertainable" information is required of all manufacturers of non-exempt[78] chemicals in

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[75] The base set selected for the HPV Challenge is based on the SIDS, or Screening Information Data Set, developed by the Chemicals Committee of the Organization for Economic Cooperation and Development (OECD). For a list of the data elements, see EPA's program guidance document, "Determining the Adequacy of Existing Data," Appendix A, at www.epa.gov/chemrtk/pubs/general/datadfin.htm.

[76] For a full description of the HPV Challenge and what it has and has not accomplished, see Denison, R.A., *High Hopes, Low Marks: A final report card on the High Production Volume Chemical Challenge*, July 2007, at www.environmentaldefense.org/hpvreportcard.

[77] See EPA, TSCA Inventory Update Rule Amendments, *Federal Register*, 7 January 2003, Vol. 68, No. 4, pp. 847-906, at www.epa.gov/fedrgstr/EPA-TOX/2003/January/Day-07/t32909.htm.

[78] Certain chemicals on the TSCA Inventory are fully or partially exempted from IUR reporting. Full exemptions apply to most polymers, and also to chemicals that are: produced in small quantities for research and development; imported as part of an article; impurities, byproducts (under certain circumstances), or non-isolated intermediates; and manufactured by a small manufacturer as defined in the regulations. Partial reporting exemptions apply to certain petroleum processing streams, other chemicals deemed to be of "low current interest" and specifically listed in the regulations, and inorganic chemicals (the latter will be subject to full reporting starting in 2011). See EPA, "Questions and Answers for Reporting for the 2006 Partial Updating of the TSCA Chemical Inventory Database," answers to questions 30-37, at www.epa.gov/opptintr/iur/pubs/guidance_qanda.pdf.

amounts of 25,000 pounds or more per year per site pertaining to the number of workers reasonably likely to be exposed to the chemical substance at the site, and the physical form(s) and the maximum concentration of the chemical substance as it leaves the submitter's possession.

For chemicals manufactured in amounts of 300,000 pounds or more per year per site,[79] additional information must be reported, to the extent it is "readily obtainable," on the number of downstream processing and use sites, numbers of workers reasonably likely to be exposed to the chemical substance across all such sites, types of commercial and consumer uses, amounts in each use category, and maximum concentrations in commercial and consumer products.

Fewer than 10,000 chemicals are now covered by any reporting requirements and only a few thousand of them will be subject to the more extensive reporting that extends to downstream processing and use information. Reporting is required only once every five years and then only for a single reporting year. U.S. EPA's experience with past IUR reporting of production data (which used to occur every four years) shows that there is enormous fluctuation from one reporting cycle to the next that must reflect underlying changes in chemical use patterns,[80] which calls into question how accurate a picture U.S. EPA has as to actual manufacturing, use and exposure for industrial chemicals.

For new chemicals, Premanufacture Notifications (PMNs) that are required to be filed at least 90 days before commencing manufacture must include basic information on anticipated use, production volume, exposure and release – to the extent it is known or reasonably foreseeable by the submitter at the premanufacture stage. TSCA does not provide for any updating of that information once manufacture actually begins, outside of any IUR reporting to which the chemical may become subject.

Environmental release information: Generation or calculation of data on direct environmental releases and exposures takes place under a few programs at the federal level. Under the U.S. EPA's Toxics Release Inventory (TRI) Program, certain types of facilities are required to annually report measured or calculated quantities of each of about 650 designated chemicals that they release to air or water or manage in the form of wastes (including through disposal, treatment, recycling, or burning for energy recovery, either on- or off-

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[79] This quantity was chosen to cover HPV chemicals, which are produced in amounts, *aggregated across all manufacturers*, of one million pounds per year or more.

[80] USEPA, National Pollution Prevention and Toxics Advisory Committee (NPPTAC), Broader Issues Work Group, "Initial Thought-Starter: How can EPA more efficiently identify potential risks and facilitate risk reduction decisions for non-HPV existing chemicals?" Draft dated October 6, 2005, pp. 3-4, at www.epa.gov/oppt/npptac/pubs/finaldraftnonhpvpaper051006.pdf; and Environmental Defense's comments on Proposed Rule, TSCA Inventory Update Reporting Revisions (70 Fed. Reg. 3658, 26 January 2005), Docket ID No. EPA-HQ-OPPT-2004-0106, accessible at www.regulations.gov (search for docket number).

site)[81] These facility-specific data are then made public. As with IUR reporting, however, the reporting thresholds have recently been raised; for most TRI chemicals, full reports detailing amounts and means of release or waste management, previously required for facilities releasing or handling more than 500 pounds annually, are now required only if more than 5,000 pounds are released or managed, as long as 2,000 pounds or less is released. Below the thresholds, only a certification is required, devoid of quantities or release/management information[82]

Environmental monitoring: the federal government also conducts limited monitoring of chemicals in environmental media. For example, in recent years the U.S. Geological Survey's (USGS) Toxic Substances Hydrology Program[83] has pioneered the analysis of selected U.S. surface and ground waters for the presence of various types of chemicals, including industrial and agricultural chemicals, human pharmaceuticals, and ingredients used in personal care and formulated consumer products. USGS data show that dozens of such chemicals can routinely be detected in such watersheds, and are found in highest concentrations just downstream of wastewater treatment plants but are also present in more pristine waters[84] As USGS points out, however, these data are often hard to interpret as water quality standards do not exist for most such chemicals and the nature and extent of their biological significance for both aquatic organisms and humans (through food chain and drinking water exposures) has yet to be determined.

Biomonitoring: Since 1999, through the Centers for Disease Control's National Health and Nutrition Examination Survey (NHANES), the federal government has measured the levels of a limited number of chemicals and their metabolites in samples of human blood and urine every two years. The latest survey was published in 2005 and tested samples collected in 2001 and 2002 for

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[81] See USEPA, "Toxics Release Inventory Reporting, Year 2005 Public Data Release, Summary of Key Findings," pp. 1-2, at www.epa.gov/tri/tridata/tri05/pdfs/Key_Findings.pdf.

[82] For 20 PBT chemicals, full reporting was previously required at any quantity of release or waste management; now, only the certification is required for facilities that manage up to 500 pounds annually of such PBTs as long as there is no environmental release. See 71 *Federal Register* 76937 (December 22, 2006), at www.epa.gov/fedrgstr/EPA-TRI/2006/December/Day-22/tri21958.htm; and OMBWatch, *Against the Public's Will*, December 2006, p. 3, at www.ombwatch.org/info/TRICommentsReport.pdf. More recently, President Bush signed an Executive Order that would likely have the effect of exempting federal facilities from TRI reporting. While federal facility reporting is not required by the law that established the TRI, Clinton-era Executive Orders extended the requirement to such facilities. On January 26, 2007, President Bush signed a new Executive Order that has the effect of rescinding this requirement, although final resolution is awaiting clarifying guidance to be issued by the Council on Environmental Quality. See OMBWatch, "Congress, White House Going in Opposite Directions on TRI," February 21, 2007, at www.ombwatch.org/article/articleview/3729/1/1?TopicID=1.

[83] See http://toxics.usgs.gov/about.html.

[84] See http://toxics.usgs.gov/highlights/pharm_watershed/ for examples of recent USGS studies.

148 chemicals. While many of the chemicals included are either "historical" (for example, banned pesticides, PCBs) or unintentionally produced substances (for example, polycyclic aromatic hydrocarbons, dioxins), human biomonitoring for substances still in commerce (for example, phthalate esters, cadmium, mercury, a variety of pesticides) has increased in the more recent survey. Such biomonitoring represents the most direct evidence for, and a means of measuring, human exposure, but to date has focused on chemicals already known to be hazardous and on chemicals that tend to bioaccumulate, which are only a subset of chemicals of potential health concern.

Section 4. More Databases and Sources of Information on Chemicals[85]

A. Resources to Identify Chemicals with Hazardous Characteristics

CA Proposition 65
www.oehha.ca.gov/prop65.html
"Prop 65" is a list of chemical that have been confirmed by the state of California to be carcinogens and or reproductive toxins. Chemicals are listed by name and by CAS #.

CA Toxic Air Contaminants List
www.arb.ca.gov/toxics/id/taclist.htm
California maintains a list of Toxic Air Contaminants (TACs) and a program for adding additional TACs.

National Toxicology Program Report on Carcinogens
ntp.niehs.nih.gov/ntp/roc/toc11.html
NTP maintains a list of chemicals that are carcinogens, likely carcinogens or probable carcinogens.

Toxics Release Inventory Resources (TRI).
www.epa.gov/tri/index.htm
TRI is a publicly available U.S. EPA database that contains information on toxic chemical releases and other waste management activities reported annually by certain covered industry groups as well as federal facilities.

Clean Air Act: Hazardous Air Pollutant List
www.epa.gov/ttn/atw/188polls.html and
www.epa.gov/ttn/atw/pollutants/atwsmod.html

[85] This summary of databases and sources of information was adapted from a book chapter by Heine. L.G. and McGrath, T. 2008 (in press), "Tools and Strategies for Greening Chemical Inventories in Small Businesses," in *Green Chemistry Metrics,* edited by A. Lapkin and D. Constable. Blackwell Publishing. Oxford, UK.

U.S. Congress amended the federal Clean Air Act in 1990 to address a large number of air pollutants that are known to cause or may reasonably be anticipated to cause adverse effects to human health or adverse environmental effects. 188 specific pollutants and chemical groups were initially identified as hazardous air pollutants (HAPs), and the list has been modified over time.

SARA/EPCRA 313 List (TRI)
www.epa.gov/tri/chemical/index.htm
Section 313 of the Emergency Planning and Community Right to Know Act (EPCRA) of 1986 was enacted to facilitate emergency planning, to minimize the effects of potential toxic chemical accidents, and to provide the public with information on releases of toxic chemicals in their communities. The current list contains 581 individually listed chemicals and 30 chemical categories.

Clean Water Act Priority Pollutants List
oaspub.epa.gov/wqsdatabase/wqsi_epa_criteria.rep_parameter
Section 307 of the CWA defines a list of 126 priority pollutants for which the U.S. EPA must establish ambient water- quality criteria and effluent limitations

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
www.epa.gov/ceppo/pubs/title3.pdf
List of over 800 chemicals from, Section 102 of CERCLA, Clean Water Act list of hazardous substances and priority pollutants (Section 211(b)(2)(a) or 307(a)), Any hazardous waste as defined under section 3001 of Resource Conservation and Recovery Act ; Clean Air Act list of hazardous air pollutants (HAPs) (section 112); Toxic Substances Control Act list of imminent hazards (Section 7)

Canadian Environmental Protection Act, 1999 (CEPA)
www.ec.gc.ca/CEPARegistry/subs_list/Toxicupdate.cfm
Under CEPA substances that are determined to be "toxic" are recommended for addition to the List of Toxic Substances (Schedule 1) of the Act.

EU Risk Phrase
ec.europa.eu/environment/dansub/consolidated_en.htm
Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labeling of dangerous substances. Annex I of the directive assigns Risk Phrases to chemical substances.

European Commission's Community Strategy for Endocrine Disrupters
http://ec.europa.eu/environment/endocrine/strategy/substances_en.htm#priority_list
The European Commission (EC) has sponsored 4 reports that evaluate a set of 553 substances selected by experts and stakeholders for assessment for endocrine disruption. Each report addresses a subset of the total set based on

priorities such as whether the chemicals are persistent, bioaccumulating or High Production Volume chemicals and/or whether or not there is already regulatory control of the chemical.

WHO Water Quality Guidelines
www.who.int/water_sanitation_health/dwq/gdwq3/en/
International standards for selected chemical, microbiology and other parameters.

The Danish List of Undesirable Substances (LOUS)
glwww.mst.dk/homepage/default.asp?Sub=http://glwww.mst.dk/udgiv/publications/2004/87-7614-477-1/html/kolofon_eng.htm
The Danish List of Undesirable Substances is a list of chemicals of concern that the government believes should be avoided to the extent feasible in commerce. Using a systematic analysis, substances are selected automatically if they meet some clear and defined criteria, eg. problematic classifications, because they are under suspicion for being PBT/vPvB (Persistent, Bioaccumulative, Toxic/very Persistent, very Bioaccumulative) or endocrine-disrupting.

International Agency for Research on Cancer (IARC)
monographs.iarc.fr/index.php
IARC Monographs are the result of interdisciplinary working groups of expert scientists who review published studies and evaluate the weight of the evidence that an agent can increase the risk of cancer. Since 1971, more than 900 agents have been evaluated, of which approximately 400 have been identified as carcinogenic or potentially carcinogenic to humans.

National Institute for Occupational Safety and Health (NIOSH) Carcinogen List
www.cdc.gov/niosh/npotocca.html
NIOSH maintains a list of substances considered to be potential occupational carcinogens.

Occupational Safety and Health Administration (OSHA)
www.osha.gov
OSHA maintains a list of potential carcinogens. In addition OSHA sets enforceable permissible exposure limits (PELS) to protect workers against the health effects of exposure to hazardous substances.

U.S. EPA Water Disinfection By-Products with Carcinogenicity Estimates (DBPCAN)
www.epa.gov/ncct/dsstox/sdf_dbpcan.html
The DBPCAN database contains predicted estimates of carcinogenic potential for 209 chemicals detected in finished drinking water samples having undergone water disinfection treatment.

PBT Profiler
www.pbtprofiler.net/
U.S. EPA has developed an evaluation tool, the PBT Profiler, which predicts PBT potential of chemicals. The PBT Profiler estimates environmental persistence (P), bioconcentration potential (B), and aquatic toxicity (T) of discrete chemicals based on their molecular structure. It is Internet-based and there is no cost for use.

Health & Safety Executive (HSE) Direct
www.hse.gov.uk/legislation/services.htm
The Health and Safety Commission is responsible for health and safety regulation in Great Britain. hsedirect is a subscription service providing full-text access to the full range of HSE guidance publications as well as the consolidated and annotated text of health and safety legislation and recent legislative changes. It includes a 'Stop- Press' feature which informs the user of very recent legislative changes. hsedirect provides full-text versions of: HSE Legal Services material (Approved Codes of Practice, 'L' series, Codes of Practice and HSR series); HSE forms; European Directives; Safety, Health and Environment cases; and summaries of British Standards. Users can choose from either 'day ticket' access or regular subscription options.

B. Chemical Toxicity data

Ecological Structure Activity Relationships (EcoSAR)
http://www.epa.gov/oppt/newchems/tools/21ecosar.htm
EcoSAR is a personal computer software program that is used to estimate the toxicity of chemicals that may enter surface waters. The program predicts the toxicity of industrial chemicals to aquatic organisms such as fish, invertebrates, and algae by using Structure Activity Relationships (SARs). The program estimates a chemical's acute (short-term) toxicity and, when available, chronic (long-term or delayed) toxicity.

Ecotox Database
http://cfpub.epa.gov/ecotox/
The Ecotox database provides single chemical toxicity information for aquatic and terrestial life. This is a useful tool for evaluating the impact of chemicals on the environment.

U.S. EPA Triage Database
http://www.epa.gov/8e_triag/
Triage is a searchable database of scientific studies on the health and environmental effects of toxic chemicals related to Section 8(e) of TSCA.

Integrated Risk Information System (IRIS) Database
http://www.epa.gov/iris/

IRIS is a database of human health effects that may result from exposure to various substances found in the environment. IRIS was initially developed for U.S. EPA staff in response to a growing demand for consistent information on chemical substances for use in risk assessments, decision-making and regulatory activities.

Toxic Substances Control Act Test Submissions (TSCATS)
http://www.rtknet.org/tsc/
TSCATS is an online index to unpublished, nonconfidential studies covering chemical testing results and adverse effects of chemicals on health and ecological systems. The studies are submitted by U.S. industry to U.S. EPA under several sections of the Toxic Substance Control Act (TSCA). There are four types of documents in the database: Section 4 chemical testing results, Section 8(d) health and safety studies, Section 8(e) substantial risk of injury to health or the environment notices, and voluntary documents submitted to U.S. EPA known as a For Your Information (FYI) notice.

High Production Volume Information System (HPVIS)
www.epa.gov/hpvis/index.html
HPVIS provides access to technical health and environmental effect information on chemicals that are manufactured or imported to US in volumes greater than 1MM lbs per year. Information in this database are submitted through HPV Challenge Program. HPVIS allows users to search for summary information, test plans, and data on high production volume chemicals.

Chemical Fact Sheets
www.epa.gov/chemfact/
The U.S. EPA's Office of Pollution Prevention and Toxics developed Chemical Fact sheets to summarize information on a particular chemical including exposure, environment and human health hazard, environmental fate, regulatory information, and whom to contact for additional information.

TOXNET
toxnet.nlm.nih.gov/
TOXNET is a series of databases on chemical toxicity hosted by the National Institutes of Medicine, which allows multiple searching options. The databases include: ChemIDplus, HSDB, Toxline, CCRIS, DART, GENETOX, IRIS, ITER, LactMed, Multi-Database, TRI, Haz-Map, Household Products, and TOXMAP.

Enhanced ToxSeek Meta-Search Engine and Clustering Tool
toxseek.nlm.nih.gov
ToxSeek is an NLM metasearch engine and clustering tool that enables the simultaneous searching of many different toxicology and environmental health information databases and web sites. This tool includes 59 databases including the TOXNET Search tool, as well as information sources from NLM, NIH, U.S. Government, International and other sources.

Library of Chemical Information
www.cfsan.fda.gov/~dms/chemist.html
The Library of Chemical information is maintained by the US Food and Drug Administration's Center for Food Safety and Applied Nutrition and is an excellent database for multiple classes of chemicals including food additives, cosmetics, color additives, pesticides and other chemicals.

Fragrance or Flavor Components Database
rifm.org/nd/Login.cfm
The Research Institute on Fragrance Materials maintains the most comprehensive worldwide source database on fragrance/flavor components including acute aquatic toxicity, biodegradation data, human health issues, e.g. carcinogenesis, sensitization. A password is required to access the database.

The Scorecard Database
www.scorecard.org/
The Scorecard Database provides information on chemical releases, risk prioritization of substances and other relevant information for chemicals and facilities.

International Chemical Safety Cards (ICSCs)
http://www.cdc.gov/niosh/ipcs/icstart.html
ICSCs are made available by the National Institute for Occupational Safety and Health. They summarize safety information in 8 languages and indexed in a variety of ways.

CleanGredients™ Database
www.cleangredients.org/
CleanGredients™ is being developed as an online database of cleaning product ingredients "A one–stop–shop for green formulation". The database contains physical chemical data, MSDSs, technical datasheets, and environmental and human health hazard data.

Cefas Building, Assessing and Standardising Information on the Atlantic Coasts (BASIC) Toxicity database
www.cefas.co.uk/basic/toxdata.htm
The BASIC toxicity database contains information on the aquatic toxicity of a number of hazardous substances. In many cases, the information is given as some sort of "safe" level such as UK Environmental Quality Standards (EQS's) or the national/international equivalent. For substances for which no such levels have been set, a brief literature review was performed in order to produce an environmental hazard/risk assessment.

PubMed®Medline®
www.pubmed.gov
MEDLINE contains bibliographic citations and author abstracts from more than 5,000 biomedical journals published in the United States and 80 other countries. The database contains over 15 million citations dating back to the mid-1950's.

Chemical Backgrounders
www.nsc.org/library/chemical/index.htm
Chemical Backgrounders is maintained by the National Safety Council and contains chemical descriptors including properties, health effects, exposure and regulatory information.

Managerial Technologies Corp (MTC) Safety Library
www.mtclibraries.com/lib/resource_locate.php?id=sl26949
The safety professional's online library, covering topics related to safety, safety management, ergonomics, fleet and environment. The Safety Library contains over 40 environmental databases and over 70 databases of chemical profiles. Subscription is required.

Chemistry Links for Chemists
www.liv.ac.uk/Chemistry/Links/refdatabases.html
This website contains a list of 105 different databases from US and around the world.

Environmental Health and Safety Freeware
www.ehsfreeware.com/cheminfo.htm
This website contains a list of almost 100 different EH&S databases that are all freeware plus several commercial databases.

Ariel™ WebInsight
www.3ecompany.com/ariel_webinsight.com
Ariel™ WebInsight is a subscription-based online compliance management tool with an easy-to-use interface and robust search, query, reporting and analysis features. The tool provides access to current, accurate, comprehensive global regulatory content containing more than 700 searchable regulatory lists covering more than 75 countries; full-text repositories of legislation, international transportation data, as well as chemical property and hazard data.

Infochems database
www.infochems.com/main/default.asp
Commercial service that provides chemical information for US and Global regulations; contains chemical, physical and toxicity information. The database includes generic chemical names and commercial chemical names.

American Conference of Governmental Industrial Hygienists (ACGIH)
www.acgih.org
ACGIH maintains annual editions of the TLVs® and BEIs® which are used worldwide as a guide for evaluation and control of workplace exposures to chemical substances and physical agents. Threshold Limit Value (TLV®) occupational exposure guidelines are recommended for more than 700 chemical substances and physical agents. There are more than 50 Biological Exposure Indices (BEIs®) that cover more than 80 chemical substances.

The Canadian Centre for Occupational Health and Safety (CCOHS's Databases)
ccinfoweb.ccohs.ca/
CCOHS's Web Information, a paid service, provides simple, one-step searching across many database collections, including:

- MSDS is a comprehensive database of more than 310,000 Material Safety Data Sheets, obtained directly from 2,000 North American manufacturers and suppliers.
- MSDS Management Service is designed to help you manage your occupational health and safety responsibilities relating to MSDSs and WHMIS requirements.
- CHEMINFO provides chemical health and safety information for more than 1,300 important workplace chemicals.
- CHEMpendium™ regularly updated information on the transport of hazardous materials, chemical toxicity, industrial chemicals and environmental contaminants, workplace safety, regulatory compliance, WHMIS and Right-to-Know, Canada's DLS and NDSL, Emergency response.
- RTECS® helps you find critical toxicological information with citations on over 160,000 chemical substances from more than 2,500 sources. This database is also available in French and Spanish.
- OSH References allows you to search over 300,000 summaries. This collection of bibliographic databases provides you with convenient access to international sources of OSH-related information including OSHline®, NIOSHTIC®, NIOSHTIC-2, HSELINE, CISILO, and Canadiana.
- Canadian enviroOSH Legislation plus Standards is a comprehensive, easy to search compilation of the full text of the Canadian health, safety and environmental legislation, critical guidelines and codes of practice from all jurisdictions and regular updates, with amendments highlighted.

CrossFire Beilstein
www.mdl.com/products/knowledge/crossfire_beilstein/
The CrossFire Beilstein database is the world's largest compilation of chemical facts. This database indexes three primary data domains: substances, reactions and literature. The substance domain stores structural information with all associated facts and literature references, including chemical, physical and

bioactivity data. The reaction domain details the preparation of substances, enabling scientists to investigate specific reaction pathways with reaction search queries. The literature domain includes citations, titles and abstracts, which are hyperlinked to the substance and reaction domain entries. It contains over 320 million experimental data, over 10 million reactions and data indexed from over 175 journals.

European chemical Substances Information System (ESIS)
ecb.jrc.it/esis/
ESIS is an IT system which provides you with information on chemicals including:

- EINECS (European Inventory of Existing Commercial chemical Substances),
- ELINCS (European List of Notified Chemical Substances),
- NLP (No-Longer Polymers),
- HPVCs (High Production Volume Chemicals) and LPVCs (Low Production Volume Chemicals), including EU Producers/Importers lists,
- C&L (Classification and Labelling), Risk and Safety Phrases, Danger etc...,
- IUCLID (International Uniform ChemicaL Information Database) Chemical Data Sheets, IUCLID Export Files, OECD-IUCLID Export Files, EUSES Export Files,
- Priority Lists, Risk Assessment process and tracking system in relation to Council Regulation (EEC) 793/93 also known as Existing Substances Regulation (ESR).

eChemPortal
webnet3.oecd.org/eChemPortal/Home.aspx
The eChemPortal is an effort of the Organisation for Economic Co-operation and Development (OECD) in collaboration with the European Commission, the United States, Canada, Japan, the International Council of Chemical Associations, the Business and Industry Advisory Committee, the World Health Organization's International Program on Chemical Safety, the United Nations Environment Programme on Chemicals and environmental non-governmental organizations.

eChemPortal offers free public access to information on properties and effects of chemical substances. It is an integrated system that allows users to simultaneously search multiple databases prepared for government chemical and review programs around the world.

The current version of eChemPortal offers the possibility to retrieve information by searching on chemical names or CAS Registry numbers. The second phase will incorporate additional search options to retrieve and compile specific hazard or other effects data (for example, toxicity endpoints) from the participating databases.

At this time, the following data bases participate in eChemPortalTM * European chemical Substances Information System (ESIS, European Commission), * CHRIP (Japan's Information on Biodegradation and Bioconcentration of the Existing Chemical Substances in the Chemical Risk information platform), * OECD HPV Database (OECD), * Screening Information Datasets for High Volume Production Chemicals (UNEP Chemicals), * HPVIS (U.S. Environmental Protection Agency), * INCHEM (IPCS).

C. Exposure assessment tools

Environmental Fate Database (EFDB)
www.syrres.com/eSc/efdb.htm
EFDB has been developed in support of U.S. EPA. It is comprised of DATALOG and BIOLOG, which contain environmental fate, microbial toxicity and biodegradation data.

U.S. EPA's Envirgreen chemistryFate Database for actives
cfpub.epa.gov/pfate/home.cfm
This database includes information on the environmental fate of pesticide actives.

U.S. EPA's OPPT Exposure Assessment Tools and Models
www.epa.gov/opptintr/exposure/index.htm
The Office of Pollution Prevention and Toxics (OPPT) has developed a series of methods, databases, and predictive models to help in evaluating what happens to chemicals when they are used and released into the environment. These tools are intended to be used by scientists and engineers familiar with exposure assessment principles.

Greatest Potential for Human Exposure report
http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/existsub/exposure/index_e.html
Health Canada Proposal for Priority Setting for Existing Substances on the Domestic Substances List under the Canadian Environmental Protection Act, 1999: Greatest Potential for Human Exposure. This report describes a proposed priority setting process of existing substances in Canada. A stakeholder meeting was convened to discuss the Complex Exposure Model (comET).

D. Hazard and Risk Assessment Tools

International Uniform Chemical Information Database (IUCLID5)
ecb.jrc.it/iuclid5/
IUCLID5 is a software tool for entering and storing information on chemicals, as well as for preparing and submitting dossiers to fulfill legislation requirements.

For the EU Chemicals Agency and Member States, it is the central data repository for all dossiers submitted, the basis for evaluating the risks of substances and requiring new information and the basis for restricting and authorizing the use of chemicals to manage risks. IUCLID data will comply with REACH, OECD, EU HPV Chemicals Program, US HPV Challenge Program, Japan Challenge Program, and EU Biocides.

Massachusetts Toxics Use Reduction Institute Pollution Prevention Options Analysis Tool (p2oasys).
www.turi.org/content/content/view/full/1125/
The Institute has developed P2OaSys to helps companies determine whether the Toxic Use Reduction (TUR) options they are considering may have unforeseen negative environmental, worker or public health impacts. P2OASys allows companies to assess the potential environmental, worker, and public health impacts of alternative technologies aimed at reducing toxics use. The goal is more comprehensive and systematic thinking about the potential hazards posed by current and alternative processes identified during the TUR planning process.

Report on the Advisory List for Self Classification of Dangerous Substances.
www.mst.dk/homepage/default.asp?Sub=http://www.mst.dk/udgiv/publications/2004/87-7614-477-1/html/default_eng.htm
The Danish EPA has developed an advisory list for self-classification of dangerous substances including 20,624 substances. The substances have been identified by means of QSAR models (Quantitative Structure-Activity Relationship) as having acute oral toxicity, sensitization, mutagenicity, carcinogenicity, and/or danger to the aquatic environment

E. Safer chemistry design tools

Sustainable Futures Program (SF)
www.epa.gov/oppt/newchems/pubs/sustainablefutures.htm
The SF program is an approach that encourages pollution prevention in new chemical development through the transfer of OPPT's chemical risk screening methodologies.

The Green Chemistry Expert System (GCES)
www.epa.gov/opptintr/greenchemistry/tools.html
GCES allows users to build a green chemical process, design a green chemical, or survey the field of green chemistry. The system is equally useful for new and existing chemicals and their synthetic processes. The GCES features are contained in five modules:

- Synthetic Methodology Assessment for Reduction Techniques (SMART)
- Green Synthetic Reactions
- Designing Safer Chemicals
- Green Solvents/Reaction Conditions

- Green Chemistry References

The Green Screen for Safer Chemicals (Green Screen)
http://www.cleanproduction.org/library/Green%20Screen%20Report.pdf
The Green Screen for Safer Chemicals is a method for assessing and benchmarking chemical alternatives based on their hazard characteristics developed by Clean Production Action. The Green Screen builds on the new chemicals assessment protocols developed by the U.S. EPA and adapted for comparing alternatives by the U.S. EPA Design for the Environment Program.

Alternatives Assessment Methodologies
www.turi.org
The Massachusetts Toxics Use Reduction Institute has developed an Alternatives Assessment Process Guidance for its analysis of substitutes to five chemicals in Massachusetts.

Safer Solvent Alternatives
www.irta.us
The Institute for Research and Technical Assistance (IRTA) identifies, develops, tests and demonstrates safer alternatives in cleaning applications, dry cleaning, paint stripping, coatings, adhesives, and lubricants.

Swedish Chemicals Inspectorate PRIO Program
www.kemi.se/templates/PRIOEngframes____4144.aspx
PRIO is a web-based tool intended to be used to preventively reduce risks to human health and the environment from chemicals. The aim of PRIO is to facilitate in the assessment of health and environmental risks of chemicals so that people who work as environmental managers, purchasers and product developers can identify the need for risk reduction. To achieve this PRIO provides a guide for decision-making that can be used in setting risk reduction priorities.

Control of Substances Hazardous to Health Regulations (COSHH)
www.coshh-essentials.org.uk/
Developed by the UK Health and Safety Executive, COSHH Essentials provides advice on controlling the use of chemicals for a range of common tasks, eg mixing.

Appendix D: Advancing Green Chemistry and Engineering through Alternatives Assessment[86]

Introduction

The goal of alternatives assessment is to identify a variety of possible alternatives to an existing process or product and to choose among them with the idea that the ultimate choice will be "greener" (i.e., more health- and environmentally protective) than the other choices or current practice. Alternatives assessment is thus a comparative process intended to generate safer or less-toxic products and practices. Achieving relatively greater safety depends on judgments about a variety of factors, which may include: relative exposures, relative toxicities, relative environmental impacts, as well as life cycle, social and economic considerations.

Goals of this Subcommittee

This subcommittee will address the role of "technology alternatives assessment" in advancing the contributions of green chemistry and engineering to the following key public policy questions:

1. How can green chemistry and engineering be used to develop products, processes, and approaches that are safer than those associated with the manufacturing, use, and disposal of existing technologies?
2. What effective alternatives to existing technologies could be adopted or developed to achieve equal or better functionality at lower risk, and possibly lower costs, representing a more socially-optimal balance of risks, benefits, and costs?
3. What incentives could be used to promote the development and/or adoption of alternative technologies?

In addressing environmental and public health risks, the subcommittee will depart from the traditional practice of undertaking a detailed risk assessment,[87] followed by risk management decisions – used in many regulatory contexts – in which the risk of a *specific* chemical or technology is often characterized *to the fullest degree possible* before risk management decisions are made about the introduction or continued use of that chemical or technology.

[86] Note: the Science Advisory Panel Subcommittee reports are products of the Subcommittee that authored the report, not the entire Panel.

[87] The National Academy of Sciences (NAS, 1983) describes risk assessment as comprised of four activities: hazard identification, dose response assessment, exposure assessment, and risk characterization. Alternatives assessment typically uses one or more of these components of risk assessment, but need not always fully characterize the risk. In a comparative analysis, for example, where exposure profiles are essentially the same, comparing relative hazard rankings and dose-response curves (i.e., potency) may suffice.

With a focus on green chemistry and engineering, the analysis typically includes one or more of the components of a traditional risk assessment, but the focus is on comparing technology-based alternatives/options that (1) are available or (2) could be developed. That is, what is assessed are the *relative* utility/functionality (benefits), costs, hazards, exposures and/or risks of the alternatives, in order to discover or identify situations that provide win-win or win-win-win opportunities. Examples are (1) flame retarding fabrics in which not only alternative flame-retarding chemicals are considered, but also non-coated fabric using new weaving methods, which are more fire resistant or slow-burning, and (2) non-fibrous alternatives to asbestos.

The emphasis is to re-frame the public-policy question from "what are the definitive risks, benefits, and costs of an existing hazardous product, process or approach" to "**what are alternative ways that exist or could be developed to achieve equal or better functionality, at lower risk and possibly cost, reflecting a more socially-optimal balance of risks, benefits and costs**". This reframing would be informed by advances in green chemistry and engineering, and would more easily allow the assessment of the *relative* risks, *relative* benefits and *relative* costs of alternative technological options.

Risk Analysis and Alternatives Assessment

Risk analysis is viewed by some as a competing paradigm to alternatives assessment. This view reflects discontent relating to, among other things, the slow pace, limited scope and "paralysis by analysis" of traditional risk assessment as it has been institutionalized in the regulatory application of setting standards limiting exposure to individual chemicals.[88] Those who take exception to a risk-based approach believe the appropriate focus of alternatives assessment should be on reducing inherent hazard, a cornerstone of the principles of green chemistry. From this perspective, the primary goal of

[88] Regulatory risk assessment evolved in response to Congress and the Supreme Court. The Supreme Court's 1980 Benzene Decision found that the Occupational Safety and Health Administration could not require reductions in workplace exposure to benzene unless an actual risk to health could be demonstrated. Congress has enacted laws calling for limits on chemical exposures that, for example, "provide an ample margin of safety to protect public health" [Clean Air Act; 42 U.S.C. §7412f], "assure protection of public health" [Clean Water Act; 33 U.S.C. §1312], provide "a reasonable certainty that no harm will result" [Food Quality Protection Act; 21 U.S.C. §346a], or "adequately assures, to the extent feasible, on the basis of the best available evidence, that no employee will suffer material impairment of health or functional capacity" [Occupational Safety and Health Act; 29 U.S.C. §655]. Regulatory agencies interpret the qualitative health-protective goals of those statutes by promulgating quantitative requirements such as air quality criteria, maximum contaminant levels, pesticide residue tolerances, and permissible exposure limits. Agencies establish those quantitative limits through the use of human health risk assessment. In that context, risk assessment provides a reproducible, transparent process that, if challenged, has a greater likelihood of surviving judicial challenge as "arbitrary and capricious" under the Administrative Procedure Act than would a less structured process.

alternatives assessment should be to identify and use an alternative chemical or non-chemical approach that is less hazardous to begin with.

Proponents of risk analysis as an intellectual discipline argue that it includes a variety of tools – data-based, expert judgment-based, both qualitative and quantitative – that can assist in the decision-making process of alternatives assessment. Risk analysis, they argue, can add scientific rigor to the alternatives assessment.

In this appendix, we discuss a variety of approaches to alternatives assessment that differ not only in the extent to which they focus on hazard or risk, but also with regard to their purpose, scope and other features. The aim is to illustrate through real-world examples a range of alternatives assessments that has been undertaken.

Examples of Programs that Use Alternatives Assessment to Advance Green Chemistry and Engineering

Table 1 compares a number of alternatives assessment programs against potential government intervention options associated with either supply or demand. Demand side interventions include government policy, regulations and other mandated activities that result in the generation of information or assessment of alternatives. Supply side interventions include education, institutional funding and economic or other incentives. While some supply side incentives such as purchasing preferences by government agencies can be mandated, they typically do not involve enforced compliance by companies who manufacture products. As such, laying out examples of alternatives assessment programs against the type of interventions that enabled them allows us to better understand how the various interventions function and what gaps are filled through different program models.

Of the seven program examples, six of them are weighted toward the supply side and are based on voluntary initiatives to identify safer and "greener" alternatives for selection by informed users. These include the U.S. EPA Design for the Environment (DfE) Flame Retardancy Partnership, the DfE Formulator Program, the Green Screen for Safer Chemicals (which builds on the DfE Partnership work), SC Johnson's GreenList®, CleanGredients™ (which builds on DfE's Formulator program), and the City of San Francisco's procurement program. The one example of a regulatory-focused technology option analysis is the demonstration of viable alternatives to solvent cleaners containing volatile organic compounds (VOCs). A brief summary of each program is provided below.

Example 1

The U.S. EPA's Design for the Environment Program (DfE) is one of its most valued partnership programs. DfE compares human health and environmental risks, and considers the performance and cost of existing and alternative products, processes and practices. The DfE Program promotes pollution prevention and other risk reduction activities in industrial sectors. To accomplish this mission:

- DfE forms partnerships with industry and other interested parties to develop information on environmental and human health impacts, performance, and cost of cleaner technologies and approaches.
- DfE disseminates information to help businesses design and redesign cost-effective products and processes that are cleaner and safer for workers and the public[89].

Through partnerships U.S. EPA's DfE supports organizations in gathering and assessing information that they may not be able to gather independently – whether due to cost or because the information is considered proprietary. Chemical manufacturers share proprietary formulations with DfE through these voluntary partnerships because of the way the hazard information is handled and presented. DfE receives full ingredient disclosure and makes the results of the hazard assessments publicly accessible but protects proprietary formulation information by not revealing exact percentages of constituents and masking the identity of certain proprietary chemicals.

A good example of a successful DfE Partnership is the Furniture Flame Retardancy Partnership[90]. Penta-Bromo Diphenyl Ether (pentaBDE) was the primary flame retardant used in low density, flexible polyurethane furniture foam. Due to concerns over its use and the fact that the chemical was found widespread in the environment and in human tissue and breast milk, pentaBDE was voluntarily phased out of production by U.S. manufacturers in January 2004. The industry needed alternatives in order to meet furniture flame retardancy requirements, but did not have the human and environmental health and safety information needed in order to compare the alternatives. DfE worked with the furniture manufacturers, foam manufacturers, and flame retardant chemical suppliers along with governmental and environmental groups to evaluate possible alternatives.

Fourteen formulations of chemical alternatives were submitted to U.S. EPA under confidentiality and they were assessed based on numerous human health and ecotoxicity endpoints in addition to bioaccumulation potential and environmental

[89] http://www.epa.gov/dfe/

[90] http://www.epa.gov/dfe/pubs/projects/flameret/index.htm

persistence. They were also screened for potential exposure to workers, users and the aquatic environment and a distinction was made between flame retardants that are reactive and those that are added to the foam. Where data gaps existed, U.S. EPA experts used models and chemical analogs to estimate the hazard for a particular endpoint. The literature and test data reviews were published in the final report, “Environmentally Preferable Options for Furniture Fire Safety: Low Density Furniture Foam”. In addition, each hazard endpoint was ranked with a concern level (High, Moderate, or Low) based on the criteria used by the U.S. EPA’s New Chemicals Program to rate the concern level of new chemicals submitted under the Toxic Substance Control Act (TSCA). DfE notes where values are based on experimental data and where values are estimated based on models or chemical analogs. A section of the table summarizing the screening results is presented below.

L = Low hazard concern N = No [a]Ongoing studies may result in a change in this endpoint
M[1] = Moderate hazard concern Y = Yes ▲Persistent degradation products expected[2]
H = High hazard concern P = Yes for pure chemical
L, *M*[1], or *H* = Endpoint assigned using estimated values and professional judgment (Structure Activity Relationships)

Company	Chemical	% in Formulation[3]	Human Health Effects							Ecotoxicity		Environmental		Potential Routes of Exposure							Reactive or Additive?
														Worker			General Population				
			Cancer Hazard	Skin Sensitizer	Reproductive	Developmental	Neurological	Systemic	Genotoxicity	Acute	Chronic	Persistence	Bioaccumulation	Inhalation	Dermal	Ingestion	Inhalation	Dermal	Ingestion	Aquatic	
Supresta	AB053																				
	Tris(1,3-dichloro-2-propyl)Phosphate CAS # 13674-87-8		**M**	**L**	**M**	**M**	**L**	**M**	**M**	**M**	**M**	**M**	*L*	N	Y	Y	N	Y	Y	Y	Additive
Supresta	AC003																				
	Proprietary I Organic phosphate ester	92-99%	*L*	**L**	**L**	**L**	*L*	*M*	**L**	**H**	**H**	**H**	**L**	P	Y	Y	N	Y	Y	Y	Additive
	Triphenyl Phosphate CAS # 115-86-6	1-8%	*L*	**L**	**L**	**L**	**L**	**M**	**L**	**H**	*H*	**L**	**L**	Y	Y	Y	Y	Y	Y	Y	Additive
Supresta	AC073																				
	Triphenyl Phosphate CAS # 115-86-6	38-48%	*L*	**L**	**L**	**L**	**L**	**M**	**L**	**H**	*H*	**L**	**L**	Y	Y	Y	Y	Y	Y	Y	Additive
	Proprietary J Aryl phosphate	40-46%	*L*	*L*	**L**	*L*	**L**	**M**	**M**[a]	*L*	*H*	**L**	*L*	Y	Y	Y	Y	Y	Y	Y	Additive
	Proprietary K Aryl phosphate	12-18%	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	P	Y	Y	N	Y	N	N	Additive
	Proprietary L Aryl phosphate	1-3%	*L*	*L*	*L*	*L*	*L*	*M*	*L*	*L*	*L*	*L*	*L*	P	Y	Y	N	Y	N	N	Additive
Supresta	Fyrol FR-2																				
	Tris(1,3-dichloro-2-propyl)phosphate CAS # 13674-87-8	99%	**M**	**L**	**M**	**M**	**L**	**M**	**M**	**M**	**M**	**M**	*L*	N	Y	Y	N	Y	Y	Y	Additive

[1] The moderate designation captures a broad range of concerns for hazard.
[2] More information on degradation products can be found in sections 4.1.1 and 5.1.
[3] Chemical concentrations are listed in descending order; only chemicals with concentrations greater than one percent in the formulation were evaluated.

U.S. EPA Furniture Flame Retardants Hazard Assessment Matrix.

<u>Example 2</u>

The DfE Formulator Program encourages and assists product formulators in designing products with more positive environmental and health profiles than conventional products[91]. Manufacturers provide full ingredient disclosure to DfE

[91] http://www.epa.gov/dfe/pubs/projects/formulat/index.htm

and the DfE review team screens every ingredient in the product for potential human health and environmental effects based on currently available information, predictive models, and expert judgment. Chemicals are assessed for hazard overall and compared to other chemicals in their class (i.e. solvents to solvents). The product formulator is informed when hazards are identified and recommendations for alternatives are made. The formulator may then reformulate the product and submit the reformulation for review. If the product then contains only those ingredients that pose the least concern among chemicals in their class, the formulator is awarded recognition and is permitted to use the DfE logo on their product which affords the formulators positive market recognition. The program ensures that only the safest functional ingredients in each class are used.

DfE uses a continuum approach, pushing toward the ideal and raising the bar after each innovation. For example, once effective floor finishes were made without zinc, this expectation was applied to all floor finishes reviewed from that time forward. More information about the DfE review criteria, current Partners and recognized products is available on the DfE website[92]. By comparing chemicals based on functionality, the variable of exposure is held constant and it is possible to use hazard assessment and continual improvement pressure to advance green chemistry.

Example 3

The Green Screen for Safer Chemicals (Green Screen) is a project of Clean Production Action, a non-governmental advocacy organization, and builds on the work of the DfE Flame Retardancy Partnership[93]. The DfE process did not rank the overall risk of the flame retardants; but rather provided the industry with screening information needed for comparing feasible alternatives for a particular functional use. However, there were many questions raised about how to compare and prioritize hazards in order to identify safer alternatives. None of the alternatives were determined to be perfectly “green” and therefore decision making involved considering tradeoffs between hazards. The Green Screen was designed to support decision making by businesses, governments, and individuals concerned with the risks posed by chemicals, to advance the development of green chemistry and to be a building block on the path to sustainable product design and sustainable material flows. The Green Screen defines four benchmarks on a path to safer chemicals, helping to provide perspective and to prioritize chemical alternatives based on hazards and combinations of hazards.

Benchmark 1 characterizes chemical products as “Avoid – Chemical of High Concern”; Benchmark 2 characterizes chemical products as “Use but Search for

[92] http://www.epa.gov/dfe/pubs/projects/formulat/formpart.htm

[93] http://www.cleanproduction.org/Green.Greenscreen.php accessed April 2008.

Safer Substitutes"; Benchmark 3 characterizes chemicals as "Use but Still Opportunity for Improvement"; and Benchmark 4 characterizes chemicals as "Prefer – Safer Chemical.

Each benchmark consists of a set of hazard criteria that encompass a combination of hazards and threshold values that a chemical along with its known and predicted breakdown products (environmental degradation products and metabolites) must pass in order to progress to the next benchmark. The criteria for each benchmark become increasingly more demanding for environmental and human health and safety, with Benchmark 4 representing the chemical with the least hazard. A publicly available case study was prepared describing the method and using the Green Screen to compare three flame retardants commonly used in television casings[94].

Example 4

SC Johnson & Son, Inc. (SC Johnson) won a Presidential Green Chemistry Award in 2006 for their GreenList™ raw material evaluation system. The voluntary, patented system was developed to help SC Johnson reduce the environment and human health impact of their products beyond regulatory requirements, to set internal goals and to track their progress[95]. GreenList™ is a leading example of how hazard assessment can be tied to metrics for product and inventory evaluation.

GreenList™ was developed by SC Johnson by first dividing their chemical inventory into chemical classes, which include over 90% of their raw materials including surfactants, solvents, propellants, insecticides, resins, chelants, preservatives, waxes, fragrances, inorganic acids and bases, non-woven fabrics, and packaging. For each chemical class, a set of 4-7 key attributes were identified that can be used to differentiate a chemical from others in the same class. These may include biodegradability, aquatic toxicity, sensitization potential, renewable resource derived, etc. Criteria were then developed for each of the 4-7 key attributes in order to rate a chemical as Best (3), Better (2), Acceptable (1) or as a Restricted Use Material (RUM) (0). For example, for the attribute, acute oral toxicity, an LD_{50}>2000mg/kg will earn a chemical a 3, while an LD_{50} of 500-2000 mg/kg a 2, and LD_{50}<500mg/kg a 1. The scores of the different attributes are then averaged to give an overall rating for a chemical within a chemical class.

The GreenList™ system also includes a "wild card". When a chemical is found on a regulatory list or is banned in a country, it is considered to have "Other

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94 Ibid.

95 US patent No 6,973,362

Significant Concerns" (OSCs). OSCs are applied to the overall rating of a chemical – not its individual attributes – to reduce the overall score by one point.

Using this system, SC Johnson scores both raw materials and formulated products, tracks the score of all raw material purchases and measures the overall percentage of materials that fall into each rating category, i.e., considered "Best" or "RUM". The scores are used to set company goals, for public reporting and to reward formulators and chemists who use the system to improve the environmental and human health profiles of individual products and product lines[96] Typically, individual product scores are not shared publicly.

Example 5

CleanGredients™ is an online database of institutional and industrial (I&I) raw materials appropriate for green product formulation that builds on the DfE Formulator Program[97]. CleanGredients™ aligns environmental and human health goals with the cleaning product industry's business objectives to support the formulation of products with human and environmental health benefits. CleanGredients™ is designed to:

- help formulators identify ingredients that have potential environmental and human health and safety benefits, and
- provide opportunity for manufacturers and producers of cleaning ingredients to showcase their ingredients with potential environmental and human health and safety benefits.

CleanGredients was launched with funding from the U.S. EPA DfE Program and aligns with the Formulator Program approach. The most common question asked by Formulator Partners was "where can I find a list of green ingredients that I can use to meet the DfE requirements". CleanGredients was developed in response to that question. It supports the identification of greener raw materials for use in greener product formulations which are tied to market recognition. DfE provides a set of screening criteria called the DfE Screen for each ingredient and/or chemical class (surfactants, solvents further divided into alcohols, esters, etc.) By listing raw materials on a publicly available platform and by identifying those that meet the DfE Screen, data acquisition and verification are leveraged and the cost of product review and verification is reduced. The first CleanGredients™ module was developed in 2006 for surfactants for hard surface and carpet cleaners, laundry and hand dish soap. As of April 2008, over 225

96 Fast Track Media LLC. (2007) SC Johnson Makes Greenlist Available Royalty-Free. [Online-Accessed May 1, 2007] Available from URL: http://www.environmentalleader.com/2007/02/22/sc-johnson-makes-greenlist-available-royalty-free/

97 http://www.cleangredients.org

companies currently subscribe. Modules for solvents, chelating agents and fragrances are under development.

In order to list ingredients on CleanGredients™, full ingredient formulation information along with data for key attributes is submitted to a third party for review. There are two benchmarks associated with listing – the first benchmark qualifies ingredients for listing. The second, higher benchmark is the DfE Screen. The reviews are carried out under confidentiality, providing verification of claims for the key ingredient attributes without compromising proprietary formulations. If valid data are not available in the literature, then test data must be provided.

Example 6

The San Francisco Department of the Environment employs two types of alternatives assessment for green procurement:

- Developing an in-depth alternatives assessment for a particular type of product (see Attachment #1: 2003 alternatives assessment for wood preservatives for various wood preservation needs)
- Identifying criteria to be used for City procurement of a particular type of product (see Attachment #2: General procurement criteria and Attachment #3: procurement award to vendor for janitorial cleaning products).

The San Francisco Department of the Environment has developed a set of general criteria for green procurement but specific criteria are developed for specific groups or types of products (see Attachment #4: General criteria for procurement categories 2006-2008).

In order to develop criteria for vendors to bid for City procurement for a particular product, the Department:

1. First finds what has been done to assess that type of product by third party green certifiers (e.g., Energy Star and Green Seal). Another useful site is GreenerChoices.org of *Consumer Reports*.
2. Next, Dept. employees, end users, and a volunteer consulting team consider if they can feasibly raise the bar on the criteria the certifiers have developed
3. The Department lists the final criteria for vendors to submit evidence their product(s) meet the criteria. Sometimes the company merely signs a letter verifying that the information in the submission is true (e.g., that their light bulbs don't contain mercury). Sometimes there are multiple criteria (e.g., for cleaning products) and the company has a third party certifier authenticate their claims.

This process is described in more detail at http://www.sfenvironment.org/downloads/library/ppoguidelines.pdf

Example 7

Another approach to Green Chemistry, listed in the table as California Regulatory Agencies, has been used in California is to identify, develop, test and demonstrate safer alternatives in industrial settings. This approach involves finding existing alternatives or developing alternatives and comparing the performance in the field and cost of the alternative with the performance and cost of the chemical, product or process used currently. The Institute for Research and Technical Assistance (IRTA), a technical nonprofit organization, has used this approach to find effective and cost effective alternatives in a variety of applications including:

- repair and maintenance cleaning
- automotive aerosol cleaning
- printing application equipment cleaning
- coating and adhesive application equipment cleaning
- consumer product paint strippers
- spotting chemicals used by the dry cleaning industry
- consumer product thinners
- lubricants

California air regulatory agencies have used the results of the demonstrations to develop regulations that restrict the VOC and toxic air contaminant content of products used in these applications. The regulations have led to the use of safer chemicals, processes and products in thousands of California firms.

Table 1. Gaps, Functions and Interventions[98]

		<-------------------Demand-side-------------------->					<-----------------Supply-side-------------------->			
Types of options > Programs /Options v	**Develop policy**	**Require to generate & submit data**	**Regulate / control prod'n or use**	**Ensure compli-ance / enforce**	**Pursue voluntary initiatives**	**Collect and share informa-tion**	**Develop economic incentives**	**Conduct new testing, research or R&D**	**Provide funding for GC**	**Educate and do outreach**
U.S. EPA DfE Partnership Projects (TOAs of flame retardants)			pentaBDE phase-out was trigger		multi-stakeholder partnership to asses alternatives	lit search, company data submissions, framework for data presentation		SAR analysis		reports, presenta-tions
U.S. EPA DfE Formulator Program review of individual cleaning and other formulated products					program for product formulators	full ingredient disclosure; ingredients profiled using test data, lit reviews, SAR and expert judgment; recommend-ations made to ensure chemicals are "best in class"	provides technical assistance and recognition (logo) for products that qualify (market advantage)	SAR analysis		website; presenta-tions; logo
Green Screen	screen out chemicals of concern or identify and adopt safer					lit search; engage chem/tox experts to profile chemicals	Green Screen label may lead to market advantage	SAR analysis		reports, website

[98] The completion of this table was done using an earlier iteration of Matrix 1 that appears in the main body of the SAP report. For this reason, the names of the column do not match those of Matrix 1.

		<-----------------Demand-side------------------>					<----------------Supply-side------------------->			
Types of options > Programs / Options v	**Develop policy**	**Require to generate & submit data**	**Regulate / control prod'n or use**	**Ensure compli-ance / enforce**	**Pursue voluntary initiatives**	**Collect and share informa-tion**	**Develop economic incentives**	**Conduct new testing, research or R&D**	**Provide funding for GC**	**Educate and do outreach**
	alternatives in the market-place					using U.S. EPA DfE approach				
SCJ Green List	Reduce environ-mental footprint; establish "green" criteria for different categories of substances	Obtain data from literature or suppliers		company restricts use of chemicals of concern	Developed voluntarily by company	identify and collect data for relevant attributes by functional use; use to assign environ-mental class categories for raw materials & packaging	reports goals & results annually to public; received recognition by winning Presidential Green Chemistry Award	need data for relevant attributes – may test if data are not currently available	Company supports program implement ation	used internally to assess overall chemical perform-ance and for sustain-ability reports; license tool to others
Clean-Gredients					companies voluntary submit ingredients for evaluation, listing as having preferable human health/env profiles	data on selected attributes – key attributes require 3rd party verification	approved ingredients are fast-tracked for DfE Formulator Program at reduced cost	testing required for key attributes if data not already available		website available by subscrip-tion; presenta-tions
City of San Francisco	TOAs to support	submission of				lit search, request for	procurement policy	may contract out for		public website;

		<-------------------Demand-side--------------------->					<-----------------Supply-side---------------------->			
Types of options > **Programs /Options v**	**Develop policy**	**Require to generate & submit data**	**Regulate / control prod'n or use**	**Ensure compli-ance / enforce**	**Pursue voluntary initiatives**	**Collect and share informa-tion**	**Develop economic incentives**	**Conduct new testing, research or R&D**	**Provide funding for GC**	**Educate and do outreach**
	procure-ment, education	information by vendors sufficient to win contract				public input, public website	provides financial incentive to produce green	assessment		outreach to vendors for input, submission of products
CA Regulatory Agencies	TOAs to support VOC regulation		regulation of VOC content of solvent cleaners			sharing of demo results		actual demo of viable use of alternatives		sharing of demo results

CA=California
DFE=Design for the Environment
TOA=Technology Options Analysis
VOC=Volatile Organic Chemical

Table 2 provides a suggested list of characteristics is intended to allow a comparison and differentiation among various approaches to alternatives assessment and identify what the unique or special aspects.

The table includes entries for each of the examples of an alternatives assessment considered by our subcommittee. Each example is in its own column, providing a side-by-side snapshot.

The list of criteria and assignments for the examples are not intended to be rigorous or exhaustive, nor to imply that all or any particular subset of elements should or must be included in an alternatives assessment, but rather to facilitate comparison and serve as a potential checklist of elements to consider.

Table 2: Characteristics useful in describing and differentiating among various approaches to alternatives assessment

Name/description of alternatives assessment example	SF	CA	DfE FR	GS	SCJ	CG	IS
Overall scope: Does the approach assess alternatives against health/environmental criteria only, or also extend to other factors such as the following?							
· Cost	x	x					x
· Performance/functionality	x	x	x	x			x
· Customer/consumer acceptance		x	x	x			
· Benefits		x				x	
· Other socio-economic parameters	x						
Health/environmental scope: Which of the following parameters does the health/environmental aspect of the approach consider when assessing and comparing alternatives?							
· Human health							
o Occupational		x	x	x	x	x	x
o Consumer		x	x	x	x	x	
o General public	x	x	x	x	x	x	x
· Environmental health							
o Ecotoxicity	x	x	x	x	x	x	
o Environmental fate/behavior		x	x	x	x	x	
· Hazard (may include dose-response)	x	x	x	x	x	x	x
· Exposure	x	x					x
· Risk (characterization and/or assessment)	x						x
· Safety (e.g., flammability, explosivity)		x	x	x			x
· Accidental release							x
Extent and nature of information available or required: Does the approach:							
· Rely on existing information to compare alternatives	x	x	x	x	x	x	
· Seek or require development of additional information?		x	x		x	x	
Broader health/environmental issues: Does the approach assess alternatives against health- or environmentally-related criteria that are broader than those used to identify a chemical/product/process/technology as one of sufficient concern to warrant alternatives assessment? For example:							
· Energy, water, or other resource consumption	x	x					x
· Contribution to climate change	x	x					
· Sourcing from sustainable/renewable resources						x	x

Table 2: Characteristics useful in describing and differentiating among various approaches to alternatives assessment

Name/description of alternatives assessment example	SF	CA	DfE FR	GS	SCJ	CG	IS
· Other							
Lifecycle considerations: Which stages/activities across the lifecycle of the chemical/ product/process/technology are included in the assessment?							
· Material sourcing	x					x	
· Production/processing	x	x					x
· Transport/storage		x					x
· Use	x	x	x	x		x	x
· Post-use waste management or recycling	x	x	x	x		x	x
Demonstration: Does the approach:							
· Include a direct demonstration of alternative(s)?		x					
· Use information from others' testing/demonstrations?	x						
· Limit itself to a "paper analysis"?			x	x	x	x	
Who performs the assessment? Does the approach specify or suggest who is expected to actually conduct the alternatives assessment?							
· Government	x		x			x	
· Industry		x			x	x	x
· Third party expert	x	x	x	x		x	
· Stakeholder process	x		x				
· Other							
Audience/decision-maker: Who is the intended audience or user of the assessment?							
· Government, e.g., to set policy regulatory requirements		x		x			x
· Industry			x	x	x	x	x
o Producer of chemical/product/process		x	x	x	x	x	
o User of chemical/product/process		x	x	x	x	x	
o Business/government/institutional purchaser	x		x	x		x	
· Consumers/public	x	x	x	x	x		
· Other							
To what extent or how does the approach take into account or consider/weigh the level of confidence or uncertainty in information derived from various sources, methods and expert judgments, especially when these factors may differ among the alternatives being compared? For example, does the method address differences such as the following?							

Table 2: Characteristics useful in describing and differentiating among various approaches to alternatives assessment

Name/description of alternatives assessment example	SF	CA	DfE FR	GS	SCJ	CG	IS
· More information about, or experience with, an established chemical already in commerce may be available than for newly emerging alternatives.			x	x	?		
· Some information may be provided or validated by government or independent third parties, while other information may come from a company producing an alternative.					?	x	
· Some alternatives may have empirical toxicity Data, while others have only been characterized using estimation models.			x	x	?	x	
· Some information may have been derived using established, validated methods, while other information may be developed using emerging or not-widely-accepted methods.			x	x	?		
· Some decisions may be derived through some Reliance on expert judgment or weight-of-evidence approaches to compensate for lack of "hard" data.			x	x	?	x	
· Other							

Key:

- SF: Examples associated with City of San Francisco initiatives
- CA: Examples associated with the State of California agencies' initiatives
- DfE FR: Example associated with U.S. EPA's Design for Environment Program Flame Retardancy Partnership
- GS: Example associated with the Green Screen for Safer Chemicals
- SCJ: Example associated with SC Johnson's Green Screen
- CG: Example associated with the CleanGredients initiative
- IS: Example from a 1997 paper published in Industrial Ecology[99]

[99] "Industrial Safety: The Neglected Issue in Industrial Ecology" in the Special Issue on Industrial Ecology, Ashford, N. A. and Côté, R. P. (eds,), Journal of Cleaner Production, 1997. 5(1/2), pp 115-121. Available at www.elsevier.com/locate/jclepro. Note that this example was not offered as a "complete" alternatives assessment; rather, it usefully emphasizes some neglected elements of other "systemic approaches;" those are the elements highlighted in the "IS" column of Table 1.

TEXT ONLY FINAL May 28, 2008

Appendix D Attachment 1:
Guidelines for Selecting Wood Preservatives

Philip Dickey
Staff Scientist
Washington Toxics Coalition

For
The San Francisco Department of the Environment

February 1, 2002

Summary

The primary wood treatments have been reviewed for their toxicity and other hazards. It is recognized that a distinction must be made between the wood preservative itself and the treated wood. However, all studies reviewed indicated that preservative chemicals do leach from treated wood and are picked up on hands from contact with the wood. Thus, the same health effects associated with the chemicals can also be caused by contact with the wood or contaminated environmental media such as soil or water.

The primary human health concerns are associated with PCP, creosote, and arsenical preservatives. All contain carcinogens, and some risk assessments have identified unacceptably high risk levels for certain exposure scenarios. In addition, PCP is contaminated with several highly toxic compounds, including dioxins.

Copper is the treatment most toxic to aquatic organisms, and copper levels are already an important issue in parts of San Francisco Bay. Although the amount of copper (or other chemicals) that leach from wood structures in or around water may in many cases be less than that expected to impact aquatic life, the same may not be true when background levels of these and other chemicals or other stressors are included. The prudent course is to minimize the use of copper in aquatic environments or where runoff is expected to occur.

PCP, some components of creosote, and some contaminants of PCP display the characteristics of persistence, bioaccumulation, and toxicity that have identified these materials as PBTs by some agency criteria. Metals such as arsenic, copper, chromium, and zinc are not considered PBTs because they do not bioaccumulate.

Some types of treated wood appear to qualify as hazardous waste in California and if discarded (except by utilities) would not legally be allowed in municipal landfills. Wood treated with arsenic is the most likely to fail state standards, but some copper treated wood may also be a disposal concern. This issue deserves more study.

Based on the information presented in this report and in consultation with the San Francisco Department of the Environment, a set of eight selection criteria were proposed for identifying acceptable wood treatments:

1. If a pressure treatment, product must be standardized by AWPA for the intended use.
2. Product must not be used in ways that EPA prohibits or recommends against.
3. Product or use must not violate state or local law, policy, or published best management practices.
4. Product may not be contaminated with dioxins.
5. Product, constituents, or contaminants may not have a score of 17 or higher as evaluated by the EPA Waste Minimization Tool.
6. Product (or components) should not contain known, likely, or probable human carcinogens.
7. For structures built in or over water, or where significant runoff is likely to occur, the use of copper should be minimized.
8. Material must not be designated as a hazardous waste.

When applied to the wood treatments for which AWPA standards exits, these criteria can select the acceptable treatments, as shown in Table 21 below.

Table 21. Summary of Acceptable Materials by Use

Description of Use	Acceptable Materials
Decks, railings, stairways, tables, benches, playground equipment, garden structures	Recycled plastic, untreated wood, painted wood, Cu8, CuN, ACC, AAC, ACQ, CC, ZnN, CBA
Piers or walkways over water or wetlands or where runoff may be significant	Recycled plastic, untreated wood, painted wood, AAC, ZnN. *Copper not preferred, but if used should be material with minimum copper content: CuN 0.5-2%, ACC 35.4%, CBA 39.1%, CC 49.8%, ACQ 53.3%*
Pilings/piers fresh water	Metal, plastic, concrete; CuN
Pilings/piers salt water	Metal, plastic, concrete; CC (sawn lumber only)
Utility poles (in soil)	Metal, fiberglass, concrete; CuN, ACQ
Utility poles (in impervious surface)	Metal, fiberglass, concrete; CuN (butt treatment preferred)
Building framing, interior, above ground, dry	Untreated wood, borates
Building framing, interior, ground contact	ACQ-B, CBA
Plywood, interior, above ground, damp	Cu8, ACC, ACQ-D, CC, CBA
Plywood, exterior, above ground	Cu8, ACC, ACQ-D, CC, CBA
Plywood, exterior, ground contact	ACC, ACQ, CBA
Plywood, exterior, ground contact, foundations	None. Use of wood discouraged for foundations.

Appendix D Attachment 2

PPO/TPC - Product Category Score Sheet

Category: Office Supplies

Sub-Category:

[ ] Chemicals
[ ] Consumables, Materials, etc.
[ ] Equipment, Hard Goods, etc.

Typical Products:

Status of Review:	**Date**
Primary review by	
Secondary review by	

General Comments:

	Points =	3	2	1	0	2	
	Health & Environmental Scoring	Probability that products in category display characteristic					Notes
1	Product Contains Carcinogen/Reproductive Toxin/Endocrine Disrup	High	Medium	Low	None	Unk	
2	Product Has Other Human Health Effects/IIAQ incl. Asthma /Safety	High	Medium	Low	None	Unk	
3	Product Contains Persistent, Bioaccum, Toxic Ingredients (PBTs)	High	Medium	Low	None	Unk	
4	Product Creates Non-Recyclable Wastes	High	Medium	Low	None	Unk	
5	Product Use Involves Inefficient Resource Consumption	High	Medium	Low	None	Unk	
6	Product Has User Community Effects (EJ/Children/Women/Sensitives)	High	Medium	Low	None	Unk	
7	Product Use Has Air Qual/Global Enviro Effects (ozone depl/climate/smog)	High	Medium	Low	None	Unk	
8	Manufacture & Use Involve Animal Effects (Aquatic Tox, Habitat & Other)	High	Medium	Low	None	Unk	
9	Manufacture Consumes Non-Renewable Resources	High	Medium	Low	None	Unk	
10	Manufacture Involves Agrichemicals / GMOs	High	Medium	Low	None	Unk	
11	Manufacture Has Source Community Effects / Trade Issues	High	Medium	Low	None	Unk	
	Point Totals =						0

Comments on Health & Environmental Scoring

	Implementation Issues	Probability that products in category display characteristic					Notes
a	High Annual City Purchase Amount ($)	High	Medium	Low	None	Unk	
b	High Potential For Cost Savings ($)	High	Medium	Low	None	Unk	
c	Satisfies City Policy / Ordinance Requirements	High	Medium	Low	None	Unk	
d	Ease of Implementation / Existing Standards	High	Medium	Low	None	Unk	
e	Potential for National Impact / Leadership	High	Medium	Low	None	Unk	
f	CCSF has not Already Addressed Products in the Category	High	Medium	Low	None	Unk	
g	Other Issues:	High	Medium	Low	None	Unk	

Comments on Implementation Issues

City of San Francisco • Precautionary Purchasing Ordinance • Revised 3/28/06 • PPO-TPC_final_scoresheet.xls

Appendix D Attachment 3

San Francisco Green Purchasing Program
Janitorial Chemicals, Soaps and Cleaners Contract Summary

San Francisco Green Purchasing Program

Janitorial Chemicals, Soaps and Cleaners Contract Summary

CONTRACT CONTENT: Janitorial Cleaners, Soaps, Tools, and Consumables	
AWARD DATE: June 1, 2007 - May 31, 2010	CONTRACT NUMBER: #83436
PREVIOUS CONTRACT: #83434 11/1/97 – 5/31/07	LAST EXTENSION:
OCA PURCHASER: Stuart Keeler	SFE LEAD: Chris Geiger

ENVIRONMENTAL/WORKER HEALTH GOALS:
Where practicable, shift to janitorial products that contain ingredients posing less hazard to the user, building occupants, and the environment in general. Specific factors addressed include: Acute toxicity, carcinogens & reproductive toxin content, eye and skin irritation, skin sensitization, combustibility, volatile organic compound content, aquatic toxicity, aquatic biodegradability, eutrophication potential, packaging, availability as a concentrate, use of fragrances, use of specific prohibited ingredients, availability of training, use of animal testing in development, labeling, skin absorption potential, and use of aerosol containers (see technical specifications below). Using EP products can reduce exposure to hazardous janitorial chemicals by about 20% (EPP Pilot Project estimate)

PERFORMANCE GOALS:
Obtain environmentally preferable products (EPP) proven effective by City of San Francisco or other government agencies.

SUMMARY & RATIONALE

Technical specifications*:* Specifications were originally developed by the SF EPP Pilot Project through a stakeholder process; see http://www.sfenvironment.org/our_programs/interests.html?ssi=9&ti=22&ii=110 . Original point-based criteria were changed to pass/fail criteria to better harmonize with Green Seal GS-37 certifications. Criteria 1-16 now correspond to Green Seal GS-37 criteria (March 2005), City of Santa Monica, CA, and Commonwealth of Massachusetts; criteria 17-19 are unique to San Francisco. Products screened were drawn from the SF EPP Pilot Project results, along with some additional products requested by City departments. Criteria are detailed in *Technical Specifications for Procurement of Janitorial Cleaners*, March 25, 2005. http://www.sfenvironment.org/downloads/library/specsjanchem05.pdf

Bid structure*.* SFE and OCA staff separated the janitorial products into three categories: (1) EPP-Only for those work areas where a number of tested EPP are known to exist; (2) Green Seal Certified for those instances where vendors have obtained GS-37 certificates, but the City has not yet tested the product; and (3) Traditional janitorial products. SFE requested specific EPP products for categories that had an abundance of complying products (general purpose cleaners, basin tub & tile cleaners, window cleaners, general purpose cleaners/degreasers). *City staff will be required to only purchase EP products in these four product categories.*

Performance testing*:* Products meeting the technical specifications were screened for the availability of performance reports from San Francisco's EPP Pilot Project, City of Seattle, WA (2003), Massachusetts, Santa Monica , CA (2004), and Ventura Co, CA. GS-37 Certification by Green Seal was also accepted as a positive performance report.

Multiple awards: Multiple awards were permitted on this contract (i.e., one vendor per item, instead of one vendor for the entire contract). It was determined that no single vendor carried a broad enough range of both EPP and traditional products.

Disclosure Requirements*:* Vendors must disclose the ingredients used in EPP, either to the City or to an independent third party certifier (e.g., Green Seal). This approach is required by the Precautionary Principle Policy of the San Francisco Environment Code (Chapter 1).

END USER INVOLVEMENT/TRAINING:
SFE met with City end users nine times in 2004 - 2006; six meetings were at department level and three meetings was combined. . Training events are planned for early 2007.

COST:
Buying EPP is expected to cost roughly the same as traditional products. Awarding the contract to multiple vendors may lower costs through competition, or increase costs through lower volume.

FUTURE OPPORTUNITIES & OBSTACLES

Training and outreach: Training and vendor support are important factors contributing to a successful transition to environmentally preferable janitorial products.

Expanding to other product subcategories: SFE will work with City departments to evaluate additional EPP and Green Seal Certified products, so that the next contract renewal may contain more preferable items (e.g., carpet cleaners, floor finish and other floor care products).

Appendix D Attachment 4

Precautionary Purchasing Ordinance, City and County of San Francisco

Key Products (1) & Product Category	Justification (2)	Key Environmental & Health Issues (3)
Computers, monitors and other accessories, **copiers and printers** (and other multi-function office machines), *and other* OFFICE EQUIPMENT	Computers are largest City contract. Opportunity to implement new EPEAT computer standard. New standards needed for other e-equipment. Opportunity to implement City's resolution on manufacturer take-back/recycling for equipment and packaging.	Carcinogen/Repro Tox/Endocrine (product), Other Human Health Effects/IIAQ (product), PBTs (product), Creates Non-Recyclable Wastes (product), Inefficient Resource Consumption (product), User Community Effects/EJ (product), Animal Effects/Aquatic Tox/Habitat (mfr, product), Consumes Non-Renewable Resources (mfr), Source Community Effects/Trade (mfr)
Food, beverages, disposable food service items, *and other* FOOD SERVICE CONSUMABLE PRODUCTS	City resolutions to promote Fair Trade- & organic-certified food/beverages; opportunities in dairy and bread contracts. City Composting Resolution promotes reusable, recyclable, or compostable food service ware.	Creates Non-Recyclable Wastes (product), User Community Effects/EJ (product), User Community Effects/EJ (product), Animal Effects/Aquatic Tox/Habitat (mfr, product), Animal Effects/Aquatic Tox/Habitat (mfr, product), Consumes Non-Renewable Resources (mfr), Agrichemicals /GMOs (mfr), Source Community Effects/Trade (mfr)
Lighting (lamps, switches, ballasts, wire, etc.), **carpet, flooring,** *and other* BUILDING MAINTENANCE CONSUMABLES	Significant purchases of lamps - opportunity to improve existing SF standards on mercury content, lamp life, and energy efficiency. Carpet, flooring, and other building materials have PVC, plasticizer, indoor air quality issues. Building materials often under service contracts, except for lighting & lumber.	PBTs (product), Consumes Non-Renewable Resources (mfr)
Electrical fixtures, furniture, *and other* BUILDING MAINTENANCE EQUIPMENT	Opportunity to replace lighting fixtures with more energy efficient/low mercury models - closely connected to lighting contract (#3 above). Opportunity to address fire retardants in furniture.	Inefficient Resource Consumption (product)
Toner and ink cartridges, office paper (copy paper, printing and writing paper, specialty paper, envelopes, etc.),	Opportunity to expand purchase of low-toxicity/remanufactured toner cartridges. Batteries already listed as Targeted (Resource Conservation Ordinance).	Creates Non-Recyclable Wastes (product), Animal Effects/Aquatic Tox/Habitat (mfr, product), Consumes Non-Renewable Resources (mfr), Agrichemicals / GMOs (mfr), Source Community

Key Products (1) & Product Category	Justification (2)	Key Environmental & Health Issues (3)
and other OFFICE CONSUMABLES		Effects/Trade (mfr)
Restroom cleaners, disinfectants, metal polishes, hard floor care products, *and other* JANITORIAL CLEANERS	Opportunity for full implementation of existing SF standards for cleaners. Finding safer metal polishes, carpet cleaners, hard floor care products, and disinfectants are current challenges.	Carcinogen/Repro Tox/Endocrine (product), Other Human Health Effects/IIAQ (product), PBTs (product), Creates Non-Recyclable Wastes (product), Inefficient Resource Consumption (product), User Community Effects/EJ (product), Air Qual/Global Enviro Effects (product), Animal Effects/Aquatic Tox/Habitat (mfr, product)
Asphalt, asphalt patching products, concrete, playground surfaces, plants, nursery supplies, *and other* GROUNDS MAINTENANCE CONSUMABLES	Environmental justice issues with city asphalt production, low-VOC asphalt/asphalt patching options available; possibility of using recycled aggregate	Inefficient Resource Consumption (product), Animal Effects/Aquatic Tox/Habitat (mfr, product)
Graffiti removal chemicals, pesticides, sidewalk cleaning products, *and other* GROUNDS MAINTENANCE CHEMICALS	Opportunity for leadership standards on graffiti removal chemicals. Inert ingredient issues with pesticides.	Source Community Effects/EJ (mfr), Animal Effects (mfr, use), Non-Renewable Resources (mfr), User Community Effects/EJ (product), Carcinogen/Repro Tox/Endocrine (product), Other Human Health Effects (product), PBTs (product)
Motor oil, fuel (diesel, bio diesel), **engine degreasers** *and other* VEHICULAR CHEMICALS	Opportunities for bio-based products; diesel one of City's largest contracts by dollar amount.	Carcinogen/Repro Tox/Endocrine (product), Other Human Health Effects/IIAQ (product), Creates Non-Recyclable Wastes (product), Air Qual/Global Enviro Effects (product), Source Community Effects/Trade (mfr)
Paints, **elevator/HVAC cleaners,** *and other* BUILDING MAINTENANCE CHEMICALS	Opportunity to improve outdated standards for paints and other maintenance chemicals.	PBTs (product), nonrenewable resources (mfr)

K E Y

(1) Key products: Products identified as highest priority during review

(2) Justification: Considerations for inclusion/exclusion of product category, outside of health and environmental factors considered in scoring.

(3) Key Environmental and Health Issues: Criteria on score sheet that received a "high concern" rating by the primary reviewer.

Note: The San Francisco Department of the Environment will address these ten "targeted product categories" first in its development of environmentally preferable purchasing specifications. Approved product lists will be developed for some of these products, and City departments may be required to purchase only from these lists.

Product Categories Not Listed as Targeted- 3/28/06
Precautionary Purchasing Ordinance, City and County of San Francisco
Product categories are listed in alphabetical order.

Product Category (1)	Key products (2)	Justification (3)	Key issues (4)	Total Points (5) & Tier (6)
ENERGY RELATED - EQUIPMENT	Solar panels, wind mills; diesel generators	**Few opportunities due to established City programs;** most equipment purchased in construction (service) agreements	Carcinogen/Repro Tox/Endocrine (product), Other Human Health Effects/IIAQ (product), PBTs (product), Creates Non-Recyclable Wastes (product), Inefficient Resource Consumption (product), User Community Effects/EJ (product), Air Qual/Global Enviro Effects (product), Animal Effects/Aquatic Tox/Habitat (mfr, product), Consumes Non-Renewable Resources (mfr), Agrichemicals / GMOs (mfr), Source Community Effects/Trade (mfr)	**18** I
ENERGY RELATED - CONSUMABLE SUPPLIES	**Electricity**	**Few opportunities due to established City programs;** diesel covered elsewhere; electricity not purchased as commodity	Carcinogen/Repro Tox/Endocrine (product), Other Human Health Effects/IIAQ (product), PBTs (product), Creates Non-Recyclable Wastes (product), Air Qual/Global Enviro Effects (product), Animal Effects/Aquatic Tox/Habitat (mfr, product), Consumes Non-Renewable Resources (mfr), Source Community Effects/Trade (mfr)	**17** I

Product Category (1)	Key products (2)	Justification (3)	Key issues (4)	Total Points (5) & Tier (6)
VEHICULAR - EQUIPMENT	**Vehicles** (cars, trucks, etc.)	**Few opportunities due to established City programs;** many vehicles are leased by City (under service agreements)	Creates Non-Recyclable Wastes (product), Inefficient Resource Consumption (product), Air Qual/Global Enviro Effects (product), Animal Effects/Aquatic Tox/Habitat (mfr, product), Consumes Non-Renewable Resources (mfr)	**12** I
MEDICAL - CHEMICALS	Drugs, laboratory chemicals	**Hospital purchases not covered by the ordinance**	Carcinogen/Repro Tox/Endocrine (product), Other Human Health Effects/IIAQ (product),	**11** II
CLOTHING & TEXTILES - CONSUMABLE SUPPLIES	**Treated fabric such as draperies** (with formaldehyde, stain resistant chemicals, etc.)	**Few opportunities due to rigid performance specifications** (uniforms)**. Predominantly service contracts**	Carcinogen/Repro Tox/Endocrine (product), Agrichemicals / GMOs (mfr), Source Community Effects/Trade (mfr)	**11** II
OFFICE - CHEMICALS	Printing ink	**Few goods purchased.** Most/all printing already converted to digital toner or soy-based ink; much printing on service agreements	Carcinogen/Repro Tox/Endocrine (product), Other Human Health Effects/IIAQ (product), PBTs (product), Air Qual/Global Enviro Effects (product), Animal Effects/Aquatic Tox/Habitat (mfr, product)	**10** II
JANITORIAL - CONSUMABLE SUPPLIES	**Janitorial papers, trash bags**	**Few opportunities due to established City programs.** Janitorial papers are already included as targeted product category under Resource Conservation Ordinance; City Composting Resolution already mandates compostable trash bags for food service operations.	Creates Non-Recyclable Wastes (product), Animal Effects/Aquatic Tox/Habitat (mfr, product), Consumes Non-Renewable Resources (mfr), Source Community Effects/Trade (mfr),	**10** II
CLOTHING & TEXTILES - CHEMICALS	Fabric treatment chemicals	**Few goods purchased**	Carcinogen/Repro Tox/Endocrine (product), PBTs (product)	**10** II

Product Category (1)	Key products (2)	Justification (3)	Key issues (4)	Total Points (5) & Tier (6)
VEHICULAR - CONSUMABLE SUPPLIES	Tires, vehicular batteries	**Predominantly service contracts** for most tires and batteries; few feasible alternatives	Creates Non-Recyclable Wastes (product)	**9** II
GROUNDS MAINTENANCE - EQUIPMENT	**Fabricated wood products** (playground equipment, picnic tables, fences, etc.)	**Few opportunities due to established City programs -** Arsenic-treated wood ordinance.	PBTs (product), Consumes Non-Renewable Resources (mfr)	**9** II
MEDICAL - EQUIPMENT	**Mattresses, mercury-containing devices** (blood pressure monitors, etc.)	**Hospital purchases exempt; few goods purchased**	Carcinogen/Repro Tox/Endocrine (product), PBTs (product)	**8** III
MEDICAL - CONSUMABLE SUPPLIES	Examination gloves	**Hospital purchases exempt, few goods purchased** except exam gloves		**8** III
JANITORIAL - EQUIPMENT	Vacuums, mops	**Few goods purchased,** low health/ environmental score	Inefficient Resource Consumption (product), Animal Effects/Aquatic Tox/Habitat (mfr, product)	**7** III
FOOD SERVICE - EQUIPMENT	**Pots and pans (containing Teflon)**	**Low health/environmental score;** large equipment installed in service agreements	PBTs (product)	**7** III
FOOD SERVICE - CHEMICALS	Dishwashing detergent	**Low health/environmental score, few goods purchased**		**4** III

<u>**K E Y**</u>

(1) Product Category: Categories of products commonly purchased by the City (based on initial public brainstorming)

(2) Key products: Products of greatest interest within the product category

(3) Justification: Considerations for inclusion/exclusion of product category, outside of health/environmental factors considered in "total point" score. These factors were listed in the "implementation" section of the scoresheet.

(4) Key issues: Criteria on scoresheet that received a "high concern" rating by the primary reviewer.

(5) Total Points: Point score on environmental/health scoresheet. High scores are of greater concern, and received higher priority as TPC

(6) Tier: **Tier I** (top 33% percentile of point scores) = high concern
Tier II (middle 33% percentile of point scores) = medium concern
Tier III (bottom 33% percentile of point scores) = low concern

Note: Under the Ordinance, the Dept. of the Environment will address these ten "targeted product categories" first in its development of environmentally preferable purchasing specifications. Approved product lists will be developed for some of these products, and City departments may be required to purchase only from these lists.

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III

Appendix E: Science Advisory Panel Meeting Notes[100]

[100] At the time of publication of the TEXT ONLY final SAP report, meeting notes for the Panel's last three conference calls had not been prepared. These meetings occurred on May 6, 8, and 16 2008, with the goal of reviewing and finalizing this report.

California Environmental Protection Agency
Department of Toxic Substances Control
Green Chemistry Initiative Science Advisory Panel
October 23, 2007

Meeting Notes

Meeting Participants

- Dr. Paul Anastas
- Dr. Nicholas Ashford
- Dr. John Balmes
- Dr. Eric Beckman
- Dr. Michael Dourson
- Dr. Gail Charnley
- Dr, Richard Denison
- Dr. Daryl Ditz
- Dr. Lynn Goldman
- Dr. John Graham
- Dr. Robert Grubbs
- Dr. Neil Hawkins
- Dr. Lauren Heine
- Dr. James Hutchison
- Dr. John Peterson Myers
- Dr. Mary O'Brien
- Dr. John Warner
- Dr. Michael Wilson
- Maureen Gorsen, DTSC
- Anne Baker, DTSC
- Jeff Wong, DTSC
- Kathy Barwick, DTSC
- Emerson - facilitator

Meeting Objectives

- Understand the purpose for the Science Advisory Panel (SAP).
- Increase understanding of the Green Chemistry Initiative and outcomes.
- Determine how the SAP will organize itself to accomplish its purpose.

Welcome/Introduction

- John Warner opened up the meeting and welcomed participants. He clarified that the role of the panel was not to reach a consensus on what the state of California should but rather to advise the decision makers around the science.
- Participants introduced themselves.
- Today's meeting agenda was reviewed.
- The draft ground rules were reviewed. Comments are below:
  - Confidentiality – we need to trust each other, so not a strict closed door on confidentiality. This means that we can converse with a colleague but not with the media. In doing so, there should be a lack of attribution to a specific panel member. We are seeking a diversity of thoughts and opinions and we do not want to suppress any members. This is a deliberative process we are engaged in.
  - There was a short discussion about developing ground rules for interacting with the media and for press releases. Nothing definitive was decided, and the issue has been added to the "Parking Lot."
  - No additional ground rules were identified at this time; SAP members were asked to forward any additional ground rules to staff.
  - No objections were identified regarding the ground rules.

DTSC – Background on the Green Chemistry Initiative (GCI)

- Jeff and Kathy provided an overview of the initiative and the work done to this point.
- On 1/1/08 DTSC will make public a Draft GCI Options Report. A one page summary (document sent to participants) was reviewed and explained.
- It was asked if the SAP could forward recommendations to the director. The answer was yes. SAP members can submit their own recommendations that are not represented by the SAP – this includes contradictory recommendations.
- Kathy (DTSC) will clarify how SAP members can put in recommendations via the website.
- There was a conversation about how DTSC selected the seven categories for the options report. The GCI work teams at DTSC selected the seven categories. They are not subject to recommendation or change.

<u>Purpose of SAP</u>
- Draft Vision and Mission statements:
  - Jeff and Kathy compiled the draft and Drs. Warner and Balmes made slight revisions.
  - Member conversation became fairly specific, particularly around including the word "processes" in the second bullet of the vision.
  - There was a concern expressed about the role of the SAP. Staff clarified that, in addition to evaluating the comments submitted via the blog, letters, and stakeholder meetings, that the SAP or any individual SAP member is free to add new ideas.
  - Based on limited time at today's meeting to wordsmith the vision and mission statements, Kathy will send out a second draft vision and mission statement based on today's conversation for review and input. Identified scope issues included ("processes" as well as "products," and life cycle analysis.

<u>Maureen Gorsen, Director, DTSC</u>
- Maureen came on the call to welcome and thank SAP members. She shared her vision of the important work of the SAP.

<u>Purpose of SAP and What Is It That We Will Actually DO and How?</u>
- This conversation delved into the particulars of how the SAP was going to accomplish its mission. Two previously sent documents were reviewed – the 10 questions on the Considerations for the GCI SAP document and the seven chapter titles from the draft options report.
- This review led to the thought that sub-committees should be formed with looking first at the 10 questions and seven options. Further thinking included:
  - Have the SAP chair and vice-chair develop a straw man subcommittee, including the possible creation of a 'synthesis' committee address cross-cutting issues between the sub-committees.
  - Complete this structure off-line and let the members know.
  - SAP members to self-select which sub-committees they want to work on.

<u>Scheduling Meetings</u>
- There will be a gathering of SAP members in San Francisco in January, 2008. Kathy will work off-line with SAP members to determine exact dates.
- Again working off-line, Kathy will identify standing dates/times for monthly conference calls.
- It was agreed that there should be one to two more conference call meetings prior to meeting in January.

Meeting Evaluation

+	Change
▪ Useful and necessary to understand the context of what we are to be about. ▪ Having the preparatory materials ahead of time.	▪ As we move forward, the ability to talk openly and creatively even if it is outside the framework. ▪ Be more succinct – specifics – less process (even though we had to do this at this first meeting).

Parking Lot

Are the GCI SAP meetings open to the public?

How will the SAP deal with the media? Should we develop ground rules for interacting with the media and for press releases?

California Environmental Protection Agency
Department of Toxic Substances Control
Green Chemistry Initiative Science Advisory Panel
November 27, 2007

Meeting Notes

Meeting Participants

- Dr. Paul Anastas
- Dr. John Balmes
- Dr. Michael Dourson
- Dr. William Carroll
- Dr. Gail Charnley
- Dr. Daryl Ditz
- Dr. Ken Geiser
- Dr. Lynn Goldman
- Dr. John Graham
- Dr. Robert Grubbs
- Dr. Neil Hawkins
- Dr. Lauren Heine
- Dr. Mary O'Brien
- Dr. Barry Trost
- Dr. John Warner
- Dr. Michael Wilson
- Dr. Katy Wolf
- Maureen Gorsen, DTSC
- Anne Baker, DTSC
- Jeff Wong, DTSC
- Kathy Barwick, DTSC
- Emerson - facilitator

Meeting Objectives

- Clarify DTSC's expectations and final product from the Science Advisory Panel.
- Develop subcommittee structure and enrollment process.
- Develop next steps for subcommittees and January 10th meeting.

Welcome/Introduction

- John Warner opened up the meeting and welcomed participants. John Balmes followed by saying a few words about the change in the ground rules to allow for public listening of the SAP meetings.
- Participants introduced themselves.
- Meeting notes from the October 23, 2007 SAP meeting were reviewed, amendments suggested, and approved with the recommended changes.
- Today's meeting agenda was reviewed and revised as follows:
  - The presentation and discussion about the Education and the Environment program was postponed until January.

Review of Mission & Vision Statements

- The revised mission/vision statement was reviewed
- There were concerns expressed about the wording of the third bullet, regarding use of the word "toxic." The concerns focused on the issue of how to distinguish substances that are less toxic from those that are more toxic. Other concerns expressed concerning the use of the word "toxic" included:
  - too narrow a scope
  - doesn't include life cycle issues
  - doesn't address persistence
  - doesn't address cumulative exposures

There was additional discussion regarding the concern that the SAP might continue to focus on how and why risk assessments are performed. The SAP agreed to leave the draft mission/vision unrevised for the present, and requested that the “draft” watermark be retained to allow for further discussion and refinement.

- There was a request for clarification on the first bullet. Because this is a correction of a clerical error in incorporating comments from the first SAP review of the vision statement, revisions were made and posted to the web work space, as follows:

  Implement strategies to stimulate a green chemistry industrial revolution to drive technological innovation and the development of safer, healthier, and more environmentally benign chemicals, products and processes across their life cycles ~~impacts~~.

Discussion: DTSC Director Maureen Gorsen

- Director Gorsen thanked the SAP for their efforts and observed that the SAP’s mission and vision statements are on target.
- Director Gorsen reviewed the document entitled “Green Chemistry Foundational Recommendations” and asked SAP members for their feedback, especially on the first two items. She then talked about the role of the SAP in advising her on green chemistry. Discussion items included:
  - The relationship of the first two items (training future scientists, incorporating green chemistry principles into the Environmental Education Initiative) to research.
  - A SAP member mentioned that the Society of Toxicologists has a fifteen-minute video on toxicity and volunteered to make it available to the panel.
  - Key findings from the two-day seminar hosted by the Office of Environmental Health Hazard Assessment were noted, including a lack of data on chemicals used in California, and the importance to businesses about having information about chemicals.
  - The need to define what is “toxic,” “bioaccumulative,” etc. in California.
  - Discussion on the use of the word “toxic.” There were suggestions to focus on the development of benign products and processes, and so bypass arguments of toxicity.
  - Suggestion to use the word “hazardous” rather than “toxic,” as a broader and more useful term.
  - Suggestion to talk about Green Chemistry in a positive sense, and avoid “toxicity” as a singular issue. There was discussion about it being easier to talk about what we mean by “green” and what is good, rather than what is bad. General sense that the discussion should be more about qualitative attributes of materials.
  - Question about the third bullet: what does “developing” mean? Assembling, rather than generating new information? Answer: yes, more the former.
  - The last two items of the “foundational” document are less concrete, and more a recognition that there needs to be something about those topics.
  - More discussion on what Director Gorsen would like from the SAP:
    - Feedback on foundational document, more specificity if possible.
    - Between January and July of 2008, we need a recommended “framework” for green chemistry. Director Gorsen would like the SAP view by May 2008.
  - Question: can the SAP submit its ideas about the “foundational” list? Answer: yes, submit soon. Ideas should be submitted to Jeff, Kathy, or the SAP work space.
  - There was a reminder to the group that while consensus is good when possible, it is not required of the SAP.

Discussion of the Draft Ground Rules

The draft ground rules were reviewed. A change to the ground rules regarding public access to the SAP meetings was discussed. DTSC staff noted that the change was made with respect to a recent lawsuit on the matter. DTSC staff affirmed that meetings of the Science Advisory Panel would be open to the public, and that subcommittee meetings will not be subject to that requirement. Comments specific to this issue included:

- Consider the trade-offs between transparency/public access and the more frank discussions that can occur in a closed session. Brainstorming may be limited.
- It is appropriate for the SAP to determine its own ground rules.
- There is a potential for the SAP efforts, and the usefulness of its product, to be undermined if the process is closed.
- Clarification was requested on conversations outside of the meetings; DTSC staff noted that the need to make SAP meetings open to the public does not affect other conversations, or subcommittee meetings of the SAP.

Other comments on the ground rules included:

- Need to define "consensus."
- There was a comment regarding potential difficulty, given the make-up of the SAP, to get a single document or point of view that the SAP endorses. The commenter suggested that instead, the SAP should facilitate expert advice and input into the process of developing the recommendations for Secretary Adams.

It was moved that the ground rules be approved; no objections were heard.

Subcommittee Structure

Dr. Warner introduced the subcommittee structure proposal, and reviewed how it was developed. Noting that there are many ways to organize, the SAP was asked to determine if there were any missing elements in the proposal.

After discussion, the following suggestions were made for revisions:

- #1, last bullet, include NGOs
- #5, add as 2nd bullet: "What are some of the major areas of concern [classes of materials processes], where alternatives are available but not being used?"
- Suggestion to add "advancing green chemistry through" to the beginning of each subcommittee, to make sure they make sense. The outcome of this discussion was that the SAP members on this committee will determine the most appropriate name for the subcommittee.
- Subcommittee membership was solicited at the end of the meeting. Results are posted on the SAP work space. Subcommittees will designate chairs & co-chairs.
- A question was asked about the operation of subcommittees relative to the overall SAP. Dr. Warner clarified: subcommittees frame the specific topics for subsequent discussions with the entire SAP (five parallel efforts).

SAP meeting in San Francisco on January 10, 2008

- Kathy briefly reviewed expectations for the January 10, 2008 SAP meeting in San Francisco, including a brief review of agenda items and travel arrangements. Initial agenda items include reports from the subcommittee, and opportunities for public comment.
- Kathy asked that after subcommittees meet that they communicate regarding ideas for agenda items.

Meeting Evaluation

SAP members were requested to provide feedback on the meeting via the SAP work space. A discussion thread entitled “Feedback on the 11.27.07 SAP meeting” has been created for this purpose. SAP members are encouraged to state what worked well, and what could be improved on in the future, in this space.

Parking Lot

How will the SAP deal with the media? Should we develop ground rules for interacting with the media and for press releases?

California Environmental Protection Agency
Department of Toxic Substances Control
Green Chemistry Initiative Science Advisory Panel
January 10, 2008 Meeting
San Francisco, California

Meeting Notes

Meeting Participants

- Dr. Paul Anastas
- Dr. Nicholas Ashford
- Dr. John Balmes
- Dr. Eric Beckman
- Dr. William Carroll
- Dr. Gail Charnley
- Dr. Richard Denison
- Dr. Daryl Ditz
- Dr. Michael Dourson
- Dr. Ken Geiser
- Dr. John Graham
- Dr. Neil Hawkins
- Dr. Lauren Heine
- Dr. Vistasp Karbhari
- Dr. John Peterson Myers
- Dr. Mary O'Brien
- Dr. Barry Trost
- Dr. John Warner
- Dr. Michael Wilson
- Dr. Katy Wolf

- Anne Baker, DTSC
- Kathy Barwick, DTSC
- Maureen Gorsen, DTSC
- Don Owen, DTSC
- Jeff Wong, DTSC
- Emerson - facilitator

Visitors:

TEXT ONLY FINAL May 28, 2008
Robert Reinhard, Morrison Foerster
Claudia Polsky, California Department of Justice
Arlene Blum, UC Berkeley
Paul DeLeo, The Soap & Detergent Association
Diana Graham, Keller & Heckman
Greg Gorder, Technology Sciences Group
Nancy Noe, Johnson & Johnson
Ann Blake, EPHC
Virginia St. Jean, San Francisco Department of Public Health
Jennifer Harris, XenoPort
Joanne McFavlin, SULG
Meg Schwarzman, UC Berkeley/COEH
Randy Fischback, Dow Chemical
Joe Gregorich, ACA
Sandy McDonald, UC Berkeley
Fareed Ferhut, CIWMB
Caroline Scruggs, Stanford University
Ansje Miller, Center for Environmental Health & CHANGE
Dana Smirin, Consultant
Andria Ventura, Clean Water Action
Andrea Lewis, Cal/EPA
Luis Cabrales, CCA
Sara Schedler, Friends of the Earth
Neil Gendel, Healthy Children Organizing Project

Meeting Objectives

- Finalize the mission/vision statement
- Hear from DTSC about stakeholder input received and understand the next steps.
- Hear about the Cal/EPA Environmental Education Initiative.
- Allow for public comment to the SAP.
- Hear reports from the five SAP subcommittees.
- Understand the SAP work process through June 2008.

Welcome/Introduction

- DTSC Director Maureen Gorsen welcomed everyone to the meeting and introduced SAP Chair Dr. John Warner and Vice-Chair Dr. John Balmes.
- John Warner welcomed participants reviewed the challenge presented to the SAP; John Balmes followed by saying a few words about the desire of Californians to see an improved chemicals policy. Dr. Balmes also referenced the new University of California report authored by SAP member Dr. Michael Wilson, entitled "Green Chemistry: Cornerstone to a Sustainable California."
- Participants introduced themselves.
- Meeting notes from the November 27, 2007 SAP meeting were reviewed, amendments suggested, and approved with the recommended changes. Recommended changes included:
  - Adding Dr. Carroll to the list of attendees
  - An editorial revision with respect to relative toxicity
  - Nonsubstantive editorial revisions
- Today's meeting agenda was reviewed; no revisions were made.
- Emerson reviewed the ground rules for today's meeting.

Review and Approval of Mission & Vision Statements

- The revised mission/vision statement was reviewed. Additional changes were made to the wording, and the mission/vision statement was approved with the requested changes.

Presentation and Discussion: DTSC Director Maureen Gorsen

- Director Gorsen gave a brief presentation, entitled "Next Steps." Included in the presentation was a specific set of questions to the SAP, as follows:
  - What is the state of the science of producing green chemicals?
  - What is the state of the scientific training related to the design, production, and use of green chemicals?
  - How would you incorporate the following into the policy framework:
    - Data
    - Alternative Analysis
    - Research and Development
    - Ph.D. Programs

- Education and the Environment Initiative
- Community Colleges

- The discussion included a number of topics and ideas, including:
    - The need to fully exploit the significant talent present on the SAP;
    - Scoping issues;
    - Further clarification of the goals of the SAP, pursuant to Director Gorsen's need for advice;
    - Reconciliation of the work conducted to date by the SAP, particularly with respect to the subcommittees, to the further clarification of the goals presented by Director Gorsen;
    - More clarification by Director Gorsen with respect to the development of a variety of green chemistry frameworks; and
    - The possible role of the SAP in reviewing the DTSC's green chemistry options report.

Other comments included:

- An observation that much of the discussion has been around the supply aspect of green chemistry and the need to also focus on demand.
- Acknowledgment of the political context of this effort.
- The potential to develop "First Principles" for evaluating green chemistry options.
- Several observations from SAP members regarding their desire to contribute meaningful and helpful advice to Director Gorsen.
- A SAP member proposed a possible structure or framework for the SAP's work including these basic ideas:
    1. willingness to change, bolstered by knowledge of alternatives;
    2. opportunity or motivation
    3. building capacity for the movement to green chemistry
- Proposal to establish another committee to build a policy framework, noting three policy frameworks suggested to date (UC report "gaps;" supply/demand framework; and the three items noted above).
- A request from agency staff to help us develop a baseline, and to help identify not just the "what," but also, who, when, where, why, etc.
- Possible need for a problem statement.
- Observation that "the industry" is not monolithic.
- Observation that the term "green chemistry" isn't quite right; that this effort also includes chemicals policy; and a suggestion to include this on a SAP meeting agenda.

With respect to the Options Report, Director Gorsen responded with a request to the SAP to think further about *frameworks* for green chemistry, and noted that the options report could be used as background for this effort.

Presentation: Andrea Lewis, Assistant Secretary, Cal/EPA
Ms. Lewis presented information about the state's Education and the Environment Initiative, and encouraged SAP members to contribute to the effort.

Public Comment
Visitors were invited to present their comments to the SAP. Emerson reviewed the ground rules for the public comment portion of the agenda. The following is a list of commentors and a summary of their comments.

- Paul DeLeo, Soap & Detergent Association: Mr. DeLeo suggested that the SAP should recommend relevant metrics (public health metrics, such as biomonitoring).
- Randy Fischback, Dow Chemical: Mr. Fischback's comments focused on the need to have a comprehensive, rather than piecemeal, chemicals program. Noting that the Dow Corporation considers Green Chemistry as including energy, toxicity, waste reduction, renewable resources, transportation security, and efficacy, he noted and approved the movement within "green chemistry" from a narrow focus on toxicity toward "life cycle analysis."
- Andria Ventura, Clean Water Action: Ms. Ventura stated her appreciation of DTSC and Cal/EPA in establishing the Green Chemistry, and her respect for the expertise of the SAP members. Ms. Ventura stated that she is concerned about the role of the SAP, and whether or not it would be called on to establish the framework for California policy. Ms. Ventura suggested that any policy should be based on the needs of the environment, protecting public health, and growing a sustainable economy. There is concern that California is losing its competitive edge in this area, due to progress in Europe and other countries.
- Robert Reinhard, Morrison & Forster: Mr. Reinhard noted that the Federal Trade Commission has issued a warning regarding "green" labels on products. He noted that it is a challenge to explain science to the public, and asked for the SAP to help explain the outcome of the Green Chemistry Initiative process to the public, in order to refrain from creating unrealistic expectations.
- Claudia Polsky, California Attorney General's Office: Ms. Polsky would like to see the SAP establish principles for intellectual independence in green chemistry research, noting that public funding is scarce, and that there is the need for public/private partnerships. A second suggestion was that the SAP not apply any political filter to its work. Ms. Polsky's third point was to answer the question of whether the SAP should engage in broader public policy issues (as brought up in earlier public comments); her response was, yes—DTSC should give deference when appropriate (e.g., with

respect to scientific issues). Finally, there was further discussion with the SAP about "intellectual independence."

- Dana Smirin, Consultant: Ms. Smirin encouraged the SAP to bring the conversation to the financial industry. Ms. Smirin that green chemistry is an aspect of compliance for the portfolio companies within funds such as CalPERS. There is a need to reach out to the design community. Ms. Smirin noted that the United States is behind the curve with respect to green chemistry, but that its strengths are that it is "risk capable" and has a culture of innovation.
- Ansje Miller, Center for Environmental Health and CHANGE: Ms. Miller noted that the SAP is advising a public agency on a path forward. Ms. Miller asked the SAP to think about its role as "science in the public interest" and not in the interest of any represented company's bottom line. The focus should be on science. Ms. Miller noted that a framework was submitted to the SAP by CHANGE and requested feedback on that framework.
- Gretchen Lee, Breast Cancer Fund: Ms. Lee expressed support for earlier comments, and expressed respect for the work of the SAP. Ms. Lee expressed some confusion about the role of the SAP and recommended that it be clarified, suggested that the SAP consider the most important things to address, suggested that the agency's questions for the SAP be consistent, and expressed concern that the SAP's advice might be overly weighted.

There was some general discussion about the SAP's work with respect to policy and science.

<u>Subcommittee Reports</u>

The SAP discussed the established subcommittee framework and how to move forward. Each of the five SAP subcommittees reported to the SAP. The short descriptors below do not necessarily reflect the full scope of each subcommittee, as work had just begun.

Subcommittee 1: Data & Related Themes

Drs. Carroll and Denison have been designated as co-conveners. The name of the subcommittee is revised to *Subcommittee on Data Needs and Availability*. The group will focus on what data are available, and who has access to data.

Subcommittee 2:

Drs. Ashford and Dourson have been designated as co-conveners. The name of the subcommittee is revised to *Advancing Green Chemistry and Engineering through Alternatives Assessment.* The group will be looking at relative risks, benefits and costs, and the issues of moving from full characterization of risks to

looking at achieving functionality at lower risks and costs. The group noted a link to Subcommittee 3's work (barriers/incentives).

Subcommittee 3:
Dr. Daryl Ditz was designated as the chair, with Dr. Bill Carroll as assistant chair. The name of the subcommittee is *Advancing Green Chemistry Through Evaluation of Incentives and Barriers.* The group is starting with a review of existing information, and discussions about what works, and what doesn't, regarding the advancement of green chemistry.

Subcommittee 4:
Dr. Kenneth Geiser will chair this subcommittee, which is called *Advancing Green Chemistry through Education and Information Dissemination.* Initial discussions included the possible addition of business schools to the topic, and the need for a "world class informational portal" for green chemistry information.

Subcommittee 5:
Dr. Paul Anastas will chair this subcommittee, called *Advancing Green Chemistry Through Science and Technology.* Initial discussions included the need to identify short-, mid- and long-term objectives.

<u>Review of the SAP process</u>
Dr. Balmes reviewed the SAP process, including the work of the subcommittees, and the potential for a "writing group" to work on the final SAP product. A crosscutting group to integrate subcommittee work was established and titled the "Synthesis Committee" (subcommittee #6), with membership consisting of the leadership of each subcommittee. The SAP agreed that the work of the Synthesis Committee should begin immediately, in order to organize and coordinate the subcommittee work.

<u>Adjournment</u>
The meeting was adjourned at 4 pm.

California Environmental Protection Agency
Department of Toxic Substances Control
Green Chemistry Initiative Science Advisory Panel
February 11, 2008 Meeting
Conference Call

Meeting Notes

Meeting Participants

- Dr. Paul Anastas
- Dr. Nicholas Ashford
- Dr. John Balmes
- Dr. Eric Beckman
- Dr. William Carroll
- Dr. Gail Charnley
- Dr. Richard Denison
- Dr. Daryl Ditz
- Dr. Michael Dourson
- Dr. Ken Geiser
- Dr. Lynn Goldman
- Dr. Robert Grubbs
- Dr. Neil Hawkins
- Dr. Mary O'Brien
- Dr. John Warner
- Dr. Michael Wilson
- Dr. Katy Wolf

- Anne Baker, DTSC
- Kathy Barwick, DTSC
- Don Owen, DTSC
- Jeff Wong, DTSC
- Emerson - facilitator

Meeting Objectives

- Approve 1/10/08 San Francisco meeting notes
- Listen to subcommittee progress reports
- Evaluate progress to date
- Confirm SAP path forward and next steps

Welcome and Introductions

- Dr. Warner welcomed participants and reviewed the agenda.
- Participants introduced themselves.
- Today's meeting agenda was reviewed; no revisions were made.
- Emerson reviewed the ground rules for today's meeting.

Review and Approval of January 10, 2008 Meeting Notes

Meeting notes from the January 10, 2008 SAP meeting were reviewed. No changes were requested and the notes were approved.

Subcommittee Reports

Subcommittees delivered brief reports on their activities to date.

- Subcommittee on Data Needs and Availability (Subcommittee 1): Dr. Richard Denison reported for the group:
    - Established a process to conduct its operations;
    - As a starting point, the group is looking at a set of questions that need to be formulated to all SAP subcommittees: what kinds of questions/issues would be illuminated by more data?
    - As a second step: the group will examine the options for generating or making those data available, including an assessment of existing data, data sources and their adequacy.
    - Subcommittee 1 has posted on the SAP web work space an "ask" of the other subcommittees to get this feedback.

  Discussion items included:
    - It's important to link the data needs with Subcommittee 2's matrix.
    - It's important to look not just at what data exist, but also how the data are organized, and whether they are accessible and useful. Are the data presented in a way that's comparable and available to use in alternative assessments?
    - Who can access the data?
    - The role of information technology systems.
    - What kinds of uses exist for the data? Knowing this will help determine form and accessibility.

- Advancing Green Chemistry and Engineering Through Alternatives Assessment (Subcommittee 2). Dr. Nick Ashford reported for the group.
    - The need for the subcommittees to work closely together.
    - Issues around mandating alternatives assessment, with the New Jersey's and Massachusetts' programs as models.
    - What is the minimum data set needed for alternatives assessments? Need to provide that information to Subcommittee 1.
    - Need to link data to specific purpose(s), and a suggestion to develop a brief list of the problems that alternatives analyses are to address.
    - Note that technology alternatives analyses is an art form rather than solely formulaic; there are judgments involved.
    - The representation of various interests is important.
    - Good for Subcommittee 1 to know that there are various kinds of alternative assessments for various purposes (e.g., a retailer, versus a city such as San Francisco).
    - A request to place an issue on the "Parking Lot," regarding the motivation for performing alternative assessments. What process/procedure at the front end warrants an alternatives assessment?

  Discussion items included:

- Interest in the process of performing alternatives assessment, as well as the criteria. Subcommittee 1 was asked whether they are working on the process of how alternatives assessments are performed.

- Advancing Green Chemistry Through Evaluation of Incentives and Barriers (SC3):
  Dr. Daryl Ditz reported for the group.
    - Subcommittee 3 has compiled options submitted by subcommittee members, in an options template. 15 options have been collected; these are posted on the SAP's work space. The purpose of collecting these options is to put the subcommittee ideas on the table, to promote dialog on possible solutions. Not resolved yet is how to move the ideas forward.
    - Subcommittee 3 is also reviewing the DTSC Green Chemistry Options Report.
    - Subcommittee 3 will gather approximately 25 options, then ask the SAP to review and comment prior to whittling the list down.

  The discussion included a comment regarding the need to link the honing of recommendations into the SC6 process.

- Advancing Green Chemistry Through Education and Information Dissemination (Subcommittee 4). Dr. Ken Geiser reported for the group.
    - Subcommittee 4 encompasses a very broad area. The group is developing recommendations with various sections being developed by subcommittee members.
    - Dr. Geiser clarified that DTSC and Cal/EPA would like to include K-12 in the SAP's work on education, as well as higher education.
    - Looking at fellowships and internships to allow for green chemistry students to get industrial green chemistry experience.
    - Looking also at integrating green chemistry concepts into business schools.
    - Looking at the development of a "world class web-based information portal" for green chemistry solutions.
    - Evaluating the usefulness of the states' technical assistance programs for businesses, and to what degree green chemistry can be introduced (e.g., state extension programs).

- Advancing Green Chemistry Through Science and Technology (Subcommittee 5). Dr. Paul Anastas reported for the group. Discussion items included:
    - This group is working closely with subcommittee 4.
    - Looking at the following issues:

  - Ways to enhance the ability of universities and industry to work together on research projects? Need to remove impediments and make California a magnet for these partnerships
  - Best mechanism to identify a portfolio of green chemistry research challenges.
  - How to provide funding for the scientific research and technological development, and leveraging existing research funding.
  - Scientific tools; infrastructure; tools & equipment.
  - Extent of education/research fellowships, etc.
  - Excellence in scientific research and recognition of green chemistry accomplishments.
- Recommendations will be generated and posted for comment.

Discussion included:
  - A recommendation to expand the verbiage from “green chemistry” to “green chemistry and engineering.”
  - Massachusetts and New Jersey both have state offices of technical assistance that are instrumental in improving environmental performance; a suggestion to include such programs in any recommendations.
  - Implications regarding intellectual property; will this subcommittee look at this? Answer: yes, that’s part of the discussion.

- Synthesis Subcommittee (Subcommittee 6):
  Dr. Warner reported for the “synthesis committee.”
  - Subcommittee 6 has had one conference call plus follow-up up work. Drs. Ashford and Denison have provided two framing alternatives (“structures”) that have been distributed to the chairs of the five subcommittees for feedback.

<u>Path Forward</u>

SAP members noted that valuable tools are being developed in the subcommittees. These tools will help to integrate the subcommittee work into a unified product from the SAP.

DTSC staff gave a short overview of what is planned for the March 25 & 26 2008 meeting in San Francisco. The meeting will be largely a working meeting of the SAP. Discussion points included:

- The time in San Francisco should be used to address problematic issues.
- It will be good to have a briefing from DTSC on 3/25, but would prefer to have that today; we need this information sooner.

- Noted the tension between having subcommittees work separately and getting the entire SAP together. There is a need to balance the time.
- Suggestion that the SAP chairs ask subcommittees to elevate issues for discussion in the whole group.
- Some subcommittees might have clear links and therefore will want to meet together in San Francisco.
- We need to start with a clear picture of what we want to accomplish, and then work within the subcommittees to formulate how to get there.
- Start with a subcommittee 6 "needs assessment."
- Check in during the March 4, 2008 conference call on these issues. Devote time for discussion of the two proposed structures.
- Assign subcommittees the job of returning comment on the proposed structures to Subcommittee 6. OR—have subcommittee leaders report back on the next conf call.
- The subcommittee structure is very positive. Is it expected that subcommittees produce a written product?
- Some SAP members haven't joined a subcommittee; need to follow up with them.
- Discussion of the need to achieve consensus. The SAP was reminded that Director Gorsen has clarified that she is not requiring consensus, but would like the SAP to identify areas of agreement.
- Suggestion to define and highlight areas of agreement and disagreement.
- Dr. Warner clarified operational issues with respect to the SAP's final product and the role of Subcommittee 6 (the synthesis committee). Subcommittee 6 will:
    - Determine how to represent the areas of agreement and disagreement;
    - Determine the nature and form of the final product, and how it wants to receive information from subcommittees;
    - Evaluate ways to frame the subcommittee outputs in a way that is comparable across the subcommittees.

  It was noted that a written product from the subcommittees is expected.

<u>Overview of Green Chemistry Initiative Current Status and Phase 2 Activities</u>
At the request of SAP members, DTSC's Don Owen gave a brief overview of the current status of the GCI, and the next steps for the agency. Information included:

- Noting the work done by GCI agency staff to extract and articulate the 818 options identified in phase one and recorded in the options report.
- There will be a new round of stakeholder meetings designed to gather information about implementing the options, including issues about how, when, by whom, how funded, and timing. These meetings will be held over the next few months.
- On a concurrent track, agency staff is identifying key elements, including options characterized by a high degree of consensus. These items are not necessarily foundational, but are actions that can be done administratively

within Cal/EPA. Internal teams will develop implementation work plans for these items.

- Draft frameworks for green chemistry will be formulated by early June 2008. Input about these frameworks will be gathered in five public workshops and the GCI website.
- By summer 2008, agency staff will prepare early drafts of possible legislative and administrative actions.
- A SAP member asked for clarification of the SAP operations relative to the work to be done in Phase 2 of the GCI:
    - GCI Phase 2 was clarified as an external process to get feedback from external parties about the recommendations. Agency staff will develop a final framework for people to react to. The SAP's role is to inform the agency regarding scientific and engineering issues related to green chemistry.

Next meeting

The next SAP meeting will be via conference call March 4, 2008 from 11 am to 1 pm PST/2 pm to 5 pm EST.

Parking Lot

A SAP member requested that the following issue be placed on the "parking lot" for resolution at a future time: Regarding the motivation for performing alternative assessments: what process/procedure at the front end warrants an alternatives assessment?

Adjournment

The meeting was adjourned at 11 am PST.

California Environmental Protection Agency
Department of Toxic Substances Control
Green Chemistry Initiative Science Advisory Panel
March 4, 2008 Meeting
Conference Call

Meeting Notes

Meeting Participants

- Dr. Paul Anastas
- Dr. Nicholas Ashford
- Dr. John Balmes
- Dr. William Carroll
- Dr. Gail Charnley
- Dr. Richard Denison
- Dr. Daryl Ditz
- Dr. Michael Dourson
- Dr. Ken Geiser
- Dr. Lynn Goldman
- Dr. Vistasp Karbhari
- Dr. Pete Myers
- Dr. Mary O'Brien
- Dr. John Warner
- Dr. Michael Wilson
- Dr. Katy Wolf

- Kathy Barwick, DTSC
- Jeff Wong, DTSC
- Emerson - facilitator

Meeting Objectives

- Approve 2/11/08 SAP conference call notes
- Listen to subcommittee progress reports
- Evaluate progress to date
- Plan for SF meeting
- Confirm SAP path forward and next steps

Welcome and Introductions

- Dr. Warner welcomed participants and reviewed the agenda.
- Roll call was taken.
- Today's meeting agenda was reviewed; no revisions were made.
- Emerson reviewed the ground rules for today's meeting.

Review and Approval of February 11, 2008 Meeting Notes

- Meeting notes from the February 11, 2008 SAP meeting were reviewed. No changes were requested. After a motion to approve the February 11, 2008 meeting notes, and a second, the meeting notes for 2/11/08 were approved.

<u>Subcommittee Reports</u>
Subcommittees delivered brief reports on their activities to date.

- Subcommittee on Data Needs and Availability (Subcommittee 1): Dr. Bill Carroll reported for the group:
    - Reiterated SC1's request to other subcommittees regarding data needs, and noted that the request and template are on the SAP's web work space. The other subcommittees were requested to send the information directly to Drs. Carroll and Denison.
    - Held internal discussions on data and information needs and availability, including data for answering specific questions.

- Advancing Green Chemistry and Engineering Through Alternatives Assessment (Subcommittee 2). Dr. Mike Dourson reported for the group.
    - Increased mutual understanding within the subcommittee.
    - Looking at the two proposed structures and trying to work into those frameworks the various examples of alternatives assessment, with the purpose of better understanding the examples and how they fit in to the structures.
    - The subcommittee had not yet envisioned a report.
    - Noted that a lot of the current green chemistry-related activities are focusing on information generation and dissemination, with less on capacity-building, which is important for the consideration of incentives and barriers related to the advancement of green chemistry.
    - Has generated a lot of materials, including examples.

- Advancing Green Chemistry Through Evaluation of Incentives and Barriers (SC3):
  Dr. Daryl Ditz reported for the group.
    - Subcommittee 3 continues to develop a sampling of potential policy options. Sixteen options have been developed to date.
    - The group is applying the proposed structures to the work done to date, and looking at the kinds of interventions (regulatory, voluntary, etc.) to identify any overall patterns. The process has revealed that some part of the structures show lots of ideas, where in other places there are gaps.

- Advancing Green Chemistry Through Education and Information Dissemination (Subcommittee 4). Dr. Ken Geiser reported for the group.

- o Subcommittee 4 has had four meetings to date. They are preparing a report divided into two sections:
    - education (including K-12, undergraduate, and graduate education), including integrating green chemistry into other disciplines, as well as free-standing green chemistry programs
    - information dissemination, on three tracks:
        - a web portal, as an access point for information on green chemistry;
        - state technical assistance components; and
        - awards and recognition programs.
- o There was further general discussion about the possible addition of the term “green engineering” to the “green chemistry” focus of this subcommittee and SAP’s work, including:
    - The need to consider nonchemical solutions
    - The possible misinterpretation of “green engineering” to include secondary/tertiary treatment and other engineering controls
    - A possible unintended consequence that “green chemistry“ may be interpreted to only include chemistry
    - A reported tendency for those using the “green engineering” term to not focus enough on the reduction of inherent hazard
    - The need for clarity in the terms used by the SAP
    - Noting that the SAP’s work has included discussions of green engineering
    - There should be a glossary of terms in the SAP’s final report
    - Request to add this to the SF meeting agenda

  The end result of the discussion was to place this issue in the “parking lot” for future consideration.

- Advancing Green Chemistry Through Science and Technology (Subcommittee 5). Dr. Paul Anastas reported for the group.
    - o Looking at the nature of the final report
    - o Compilation of a set of recommendations
    - o Some of the discussion is occurring in small groups and one-on-one discussions, including:
        - How to best provide funding for research
        - Identify the major research & development challenges
        - How to leverage existing funding and approaches
        - Developing and fostering university/industry partnerships
        - Collaborations between universities and national laboratories
        - Recognition of scientific accomplishments
        - Tools, including instrumentation, computational tools

- Some overlap with other subcommittee topics (especially SC4)

- Synthesis Subcommittee (Subcommittee 6):
  Dr. Warner reported for the "synthesis committee:"
  - Subcommittee 6 is working on how to synthesize the final product from the SAP. Guided by the two framework documents.
  - Proposing sample Tables of Contents to describe the final report, as a guiding principle. A final proposal will go to the SAP for the March meeting in San Francisco.
  - The final report will include a glossary
  - It was noted that both proposed organizational structures, or frameworks, are being used by the subcommittees to organize their work. Some are making modifications to the frameworks to increase their utility. A request for suggestions for further modifications was made.
  - A SAP member asked whether DTSC's implementation of Phase 2 of the Green Chemistry Initiative continues to use the same organizational approach (categories). DTSC staff responded with yes, current work is based on the Phase 1 structure and the options report. The stakeholder meetings scheduled for Phase 2 are designed to get a better characterizations of the options (who, what, when, how). Staff will then perform a comparative analysis of options. The chapter headings in the Green Chemistry Options Report are still being used as an organizing principle. Teams within Cal/EPA and other relevant state agencies are being assembled for developing implementation plans for early action items.
  - It was noted that many recommendations under discussion call for actions outside of DTSC's capability; there was a suggestion that the SAP provide a briefing or presentation to the Green Chemistry Leadership Council.

Path Forward

Staff reviewed the schedule for SAP activities. There was discussion about the nature of the two-day meeting in San Francisco scheduled for March 25-26, 2008.

There was a suggestion to make sure the web space postings are complete.

There was a request for a brief instruction email from Drs. Warner & Balmes delineating what materials should be posted.

There was a request for a general email to everyone regarding access to the SAP web space.

Next meeting
The next SAP meeting will be in San Francisco, California on March 25-26, 2008. There was discussion about the nature of the work to be done at that meeting, including a request for the Synthesis Subcommittee to meet very soon and provide clarity and guidance to the other subcommittees.

There was a reminder to the subcommittees to provide a response to Subcommittee 1's request for input on data needs.

Parking Lot
A SAP member requested that the following issue be placed on the "parking lot" for resolution at a future time: Regarding the motivation for performing alternative assessments: what process/procedure at the front end warrants an alternatives assessment?

Add "green engineering"

Adjournment
The meeting was adjourned at 11 am PST.

California Environmental Protection Agency
Department of Toxic Substances Control
Green Chemistry Initiative Science Advisory Panel
March 25 & 26, 2008 Meeting
San Francisco, CA

Meeting Notes

Meeting Participants

- Dr. Nicholas Ashford
- Dr. John Balmes
- Dr. William Carroll
- Dr. Gail Charnley
- Dr. Richard Denison
- Dr. Daryl Ditz
- Dr. Michael Dourson
- Dr. Ken Geiser
- Dr. Lynn Goldman
- Dr. Neil Hawkins
- Dr. Lauren Heine
- Dr. Vistasp Karbhari
- Dr. John Warner
- Dr. Michael Wilson
- Dr. Katy Wolf

Staff:

- Kathy Barwick, DTSC
- Cathy Cooke, DTSC
- Don Owen, DTSC
- Jeff Wong, DTSC
- Emerson – facilitator

- Guest: Sara Hoover, OEHHA

Meeting Objectives

– Approve 3/4/08 SAP conference call notes
– Working meeting of the SAP toward its final advice on advancing green chemistry
– Work toward preparation of the final SAP report
– Hear public comment

Welcome and Introductions

Dr. Balmes welcomed participants and reviewed the agenda.

- o Meet as a panel to review SC work. Not necessarily to come to agreement about policy options, but to review what the subcommittees have done, their lists of options/recommendations.
- o Not a consensus process. Trying to catalog policy options for the state re green chemistry/policy. The synthesis subcommittee (SC 6) will take stock at the end of the day.

Participants introduced themselves.
Today's meeting agenda was reviewed; no revisions were made.
Emerson reviewed the ground rules for today's meeting

– Emerson: review the packets.
  - o sap mission—advisory, recommendations
  - o SC membership
  - o ground rules.
  - o agenda review

Review and Approval of March 4, 2008 Meeting Notes

The draft meeting notes from the March 4, 2008 SAP conference call were reviewed. One editorial change was requested. The meeting notes were approved as revised. Motion to approve, seconded, approved as corrected.

Brief subcommittee report-outs

The five subcommittees reported on progress.

SC1 Data

Dr. Carroll reporting: listing of data sources, characterizing what's out there, and making that available as a resource. Starting with work Dr. Denison has done.

SC2 Alternatives assessment

Dr. Dourson reporting: the group is mapping alternatives assessment processes into the Denison framework.

SC3 Barriers & Incentives

Dr. Ditz reporting: developed a one-page template for a description of policy options, with eighteen developed to date. The group has attempted to put the 18 ideas into both organizational matrices. Several of the options also fit into other subcommittees.

SC4 Education & Information

Dr. Geiser reporting: overview of progress to date. Fitting into the two frameworks was not difficult; they neither help nor hinder the recommendations. We noted that most of the options are supply-side. Looking at education (teacher training materials) and information dissemination. Looking at ideas such as a web portal, recognition, etc.

There was a general discussion of the evolution of the table of contents for the SAP's final report, regarding the origins of the table of contents and the "blueprint" document. The table of contents was developed by SC6, and the "blueprint" evolved from the table of contents.

SC5 Science

Dr. Karbhari reported for the group, and walked the group through the draft report, with 6 recommendations. For background, as a green chemistry driver, create an engine in California for building healthy

economy and community. Recognize that California has a large number of building blocks, but it's uncoordinated, unrecognized and underutilized. Partnerships & collaborations are key, as are visibility & recognition are also key drivers. An overriding recommendation is to ensure the integrity of green chemistry & technology. To support GC research & development efforts in California establish a $10k GC research fund. $250k grants, 40 across the state. Must be overhead-free.

There was a general discussion about needed data and decision-making, including topics associated with data required for risk assessment, the level of information required to perform risk characterization, and potential for making qualitative judgments, data required for alternatives assessments, and nonlinearities (low-dose effects, etc.).

As an example of other data uses, the SAP discussed the Washington state alternatives assessment that supported its deca regulations (using qsars). Dr. Geiser offered to map additional examples.

There was a discussion regarding the SAP's process for Wednesday March 26.

The SAP spent the last part of the day working to group the ideas.

Adjourn: 5:30 pm PST.

March 26, 2008

Members of the public in attendance:
– Darrell Thacker, California Office of Homeland Security
– Paul DeLeo, Soap & Detergent Association
– Juanita Martinez, KP Public Affairs
– Greg Hemsworth, Veolia
– Rebecca Sutton, Environmental Working Group
– Debbie Raphael, City of San Francisco
– Ansje Miller, Center for Environmental Health, CHANGE
– Laura Metz Duncan, Berridge & Diamond
– Megan Schwarzman, UC Berkeley COEH
– Gretchen Lee, Breast Cancer Fund
– Andria Ventura, Clean Water Action
– Diana Graham, Keller & Heckman LLP
– Claudia Polsky, DTSC

<u>Welcome and Introductions</u>
Dr. Warner welcomed members of the public.

Don Owen provided an update on the DTSC's Green Chemistry Initiative.

Discussion included:

- "Key elements" "early action items:" concerned that the information generation section has been removed from the GCI web site. Response: we found that category is large and so vaguely defined; 47% of the Phase 1 comments are related to this issue. We should have internally prepared a baseline. I invite further comment/advice on what to do with respect to information. At now, the topic is too large and unspecific within our current time frame.

- Regarding the baseline, why could that not be an early action item? Response: excellent idea. Rather than developing an action plan for using the data, but instead develop an implementation plan to do the baseline. Dr. Denison volunteered to help.

Public comment

1. Paul DeLeo Soap & Detergent Association

- I encourage you to look at broad-based support. I understand that the SAP is not consensus-based but I ask for designation of recommendations with broad support, to begin the work.
- Data, data transparency: industry is on board with transparency issues. There should be publicly-available hazard data sets. We need to recognize that when we're looking at "green chemistry," we're talking about new chemistries, with less data than existing chemistries. Industry is comfortable with the concept of ingredient disclosure on consumer products.
- Related to alternatives: prioritize chemicals, identify chemicals of concern. Massachusetts and Canada have similar programs. Develop metrics on chemicals of concern.

SAP members had several questions for Mr. DeLeo:

- SAP member: does your association represent mostly manufacturers? Answer: about 1/3 chemical manufacturers, 2/3 formulators. There is currently much transition from petroleum to plant-based materials.
- SAP member: have you had discussions about who would produce the data & information? Answer: generally, the manufacturer of a particular chemical; we expect it to support its chemical, and defend the information. Question: is it your sense that they have that information? Answer: yes, largely. There are some gaps some information relies on models. For testing, they are trying to transition out of animal testing, which is a big challenge.
- SAP member: how to propose a list of priority chemicals? Answer: combine hazard data plus exposure; primarily a risk-based approach.
- SAP member: what would you warn us about? What is industry afraid of coming out of this process? Answer: mandatory across-the-board registration

for every chemical. In Canada, 85% of Canada chemicals are not of high concern. Industry is more comfortable with a prioritization approach.
- SAP member: I note California's unique characteristics (Prop 65, etc.). I see a potential parallel with Prop 65. You mentioned new emphasis on nonanimal toxicity testing. No one's really got a handle on that. Answer: new methodologies: issue of low-dose effects, that's a huge open question.
- SAP member: do you have a suggestion for how California would assign priorities? Answer: look at existing databases. Canada model could be used, or U. S. EPA's IUR (Inventory Update Reporting) program. Do a first cut; use data not available in California.

2. Rebecca Sutton, Environmental Working Group: we have a short written statement (attached at the end of these notes). Our primary comment is, do not rely solely on voluntary action; we also need mandatory enforceable standards.

SAP members had several questions for Ms. Sutton:
- SAP member: I appreciate your comment regarding relying only on voluntary actions. What aspects about the initiative have led you to believe that may be the outcome? Answer: I'm just concerned; there are many difficult issues.
- SAP member: any examples of examples of "mandatory enforceable standards?" Answer: not at this time. We are currently working on the federal Safe Chemicals Act.

3. Ansje Miller, Center for Environmental Health, CHANGE: I would like to thank SAP members for their participation. This is critical for health AND economic opportunities. We need strong recommendations from the SAP. 2nd point: at the last SAP meeting, I asked if you had had a chance to look at the CHANGE framework; have you looked at that framework? I am also interested in whether this panel has reviewed the frameworks from DTSC. Finally, it's challenging to comment with no documents to comment on. Here is what we'd like to see:
- Information piece: make sure we have all the info about all the chemicals that are out there, using up to date testing methodology. We need information about chemicals' hazard traits, and their uses.
- We need more information, but we know enough to take action on known bad actors. We have lists already (prop 65) we can use to take action.
- Burden of proof: we would like to see a "no data no market" policy. Industry should demonstrate safety before putting chemicals in products.

SAP members had several questions for Ms. Miller:
- SAP member: I like the CHANGE "building blocks for Green Chemistry." Discussions in this group capture all or most of those principles. You did a good job of linking the gaps/market failures with motivating innovation in green chemistry.
- SAP member: I'm a toxicologist. Do you have an idea of how to define "safe." Answer: battery of tests should be developed. Chemicals should have to go through the entire battery of tests to take action.

- SAP member: I read the CHANGE letter; it's well thought-out. Regarding "burden of proof": this is an area where REACH dramatically changes how the system works. Are you advocating a REACH-like approach? Or something shorter? Answer: put the burden of proof on industry.
- SAP member: I looked at your framework, and thought it was very good. Do you have thoughts about what we should address now? Answer: not ready at this point, but there are lists we could start with (e.g., Prop 65 list).
- SAP member: in the creation of the Prop 65 list, there was a reliance on authoritative bodies; California used others' data. Not all the data was developed through new testing. I'm wondering if we can leverage other data (e.g., Canada list). How would you feel about us using those lists? Build on their work. Creating an inventory is huge. Could be similar to REACH. Answer: those are excellent starting points. At the same time, have to look at new chemicals coming on the market. California doesn't have to act alone (Interstate Clearinghouse; use REACH, DSL, etc.)
- SAP member: thank you for your remarks. The Canadian DSL, and EU REACH processes are much more collaborative. Regulatory processes here (federal) are much more confrontational. There's a faster pace of real change when it's more collaborative. How would you feel about a more collaborative process in California? Answer: hard to answer without knowing what it would look like.
- SAP member: thanks for the CHANGE comments, they are very helpful. We are looking at information dissemination. It's one thing to generate information, and another to get the information out to people for decision-making. What kinds of information (e.g. ingredient lists, information about where chemicals are in the state, what's needed for green chemistry alternatives assessment. Answer: ingredient list. Known and potential uses; hazard traits; known safer alternatives.
- SAP member: would CHANGE be clearer and provide more information? Answer: yes.
- SAP member: the CHANGE letter does indicate types of chemicals for priority action: bioaccumulative, persistent, those with known ecological effects, those in children's products. This is helpful to think about.

4. Gretchen Lee: Breast Cancer Fund: I would like to echo Ansje's comments and commend your work on this accelerated process. It's difficult to give public comment when I don't know what your thinking is. Next time, please provide information ahead of time. My recommendations:

- California needs a strong regulatory framework. Voluntary is good, but the regulatory framework is needed. We are already in a voluntary environment. Some volunteer, most do not. We need minimum data requirements for specific hazard traits. We need to invest in test methods, for endocrine disruption, neurotoxicity, respiratory toxicity.
- We should start now to eliminate bad actors. Continuous improvement. When we have the test methods for endocrine disruption, we can start taking action.

LEED is a good model; it changes over time as more information is developed.
- Burden of proof: no data, no market. Untie regulator's hands so they can take action without proof beyond ALL doubt.
- We urge you to be bold and visionary; don't hold back. This is an extraordinary opportunity. Be aggressive.

SAP members had several questions for Ms. Lee:
- SAP member: do you have more information about LEED? Answer: standards change over time, incorporates new information over time. Key: continuous improvement. Agree with a SAP member's call for collaboration, but only if all parties have the same goal.
- SAP member: appreciate you bringing up LEED. Good illustration of where guidance, standards, and market forces, can produce dramatic results very quickly. No regulations for this, but people expect that these principles are being followed. Process: developing principles, sharing information. Also need some regulatory enhancement, to deal with bad actors. Both approaches have merit. Something very clear, platform for consumer products, that help drive market forces, will result in quick progress.
- SAP member: as you know, all chemicals are hazardous depending on the dose. How is your community work in that concept of dose? Ideas that could guide us? Answer: new science re: "dose makes the poison," timing of exposure, different genetic responses, and low-dose exposures. You can't look just at dose-response. We must start looking at intrinsic hazard, not dose. Also, stop looking at the average person, but instead look to protecting the most sensitive.

5. Debbie Raphael, City and County of San Francisco: Data: on the ground, trying to do chemicals policy at the local level, it calls instead for state and federal action). I'm representing not just San Francisco, but also ten "Green Cities California." We are meeting regularly to effect change at the state level. Those cities support what I'm saying today.

In a current project, we take what we know and translate it for the public, so residents can make informed decisions. For cleaning products, we spent thousands of hours to identify what's in a cleaning product. I need an MSDS that is easy to find. The authority exists for this. I need to know, where are these chemicals in products? Where are my constituents being exposed to a certain chemical (e.g., DHP)? The state of Massachusetts has a fact sheet on DHP, where is it used, etc. I can use that to make decisions. I need this in California.

The U.S. Building Council is afraid San Francisco will mandate LEED. LEED is a leadership standard. LEED: Title 24 in California sets minimum standards. LEED doesn't set a bottom standard; we need that. LEED /Green Seal doesn't help me. Set the bar low, set incentives high, and give me the information I need for

decision-making. We need to ask the right questions, share the same goal (health of children and the planet).

- Data:
  - accessible data: need searchable database, expanded MSDS
  - completeness of data
  - baseline information: what data does the state collect now?
  - How chemicals are used in California; what products contain each chemical (i.e., Massachusetts DEHP fact sheet)
- Setting the bar: need to act on “bad actors” to ensure products meet some minimum standard (e.g., Title 24 sets the bar on energy efficiency)
- Regulatory authority: agency like DTSC must have the authority to take action. The legislature is the wrong place to debate phthalates.
- Language matters. Need to explain and be clear: there are near, medium and longer term options.

SAP members had several questions for Ms. Raphael:

- SAP member: have you been able to determine what consumers can and will do? Even with very toxic products, you can’t put very much information on a label that people will assimilate. What you do put there has to be very recognizable symbology. What fraction of consumers will go on the internet, take it to the store, etc.? Answer: I was part of the Consumer Labeling Initiative. Symbols are key. In San Francisco, we found that people listen to trusted voices. The trusted voice is sometimes government, sometimes not. Trusted voices include day care centers, schools, and parent groups. Those are the people that want my lists, not the consumer. Some consumers might want a web site. Labels are sometimes good, beware of greenwashing. The basic assumption that products are safe is reasonable, supporting the idea that we should eliminate substances that we know aren’t safe.
- SAP member: the decision-making about consumption is not at the consumer level. Consumer: color, picture, recollections regarding advertising. When Wal-Mart makes the decision about what goes on the shelf, when San Francisco does procurement: that is where the consumption decisions are made. Those people also can’t find the information they need. When you plea that you do not have the information to make decisions about a safe line of products, that is very important for green chemistry. Regarding your comment about the inadequacy of the MSDS, what information, through what channels, would you feel most comfortable regarding getting the information that you need? Answer: I need to know what is in a product (MSDS does some of this). I am frustrated with the idea of proprietary ingredients. Second, I need to know, for each ingredient, what do we know about it (e.g., REACH, DSL screens)? Exposure is important to me, acute exposure issues are important as well. One of the challenges: when we prioritize, is how to weight? Corrosivity vs aquatic toxicity, etc., these are related to expected use. I’m worried about asthma, the data are poor (no screen). Which cleaning

products might be an asthma trigger? That's a data gap on an outcome we're struggling with.

– SAP member: would the portal we've been discussing be helpful? Answer: searchable data bases are my favorite. DPR has a great searchable data base for products. I would like to have that for everything sold in California. Linked to other databases that are updated.
– SAP member: Thanks for your comments. Another wrinkle in the data question: which information is not there? Unsung aspects of what Canada did: limited to judgments based on existing criteria. Identified thousands of chemicals with little data. Confidence assigned was related to confidence in the source data. We need to know what we don't know. From your perspective, in your role, is identifying the unknowns part of your problem? Answer: if there's a gap, we assume the worse about a chemical. My perfect database would identify those gaps. Gretchen's "continuous improvement" idea is important here.
– SAP member: are there a few initiatives that the state would do, what would be most helpful? I heard two: 1) making information more available, and 2) raise the floor. Are there other things? Answer: raising the bar, the information. One thing that's very challenging: reason for this conversation: TSCA is broken, other countries are looking at changing how regulate chemicals, California is doing the same. A department like DTSC needs more authority to take quicker action. The legislation should not be debating this on a chemical by chemical level.
– SAP member: Third complication: dose & timing issue. Exposure/dose: doing this at the local level is inappropriate. Mantra: don't let the perfect be the enemy of the good. Err on the side of precaution. If we can't determine a safe dose, then ask, is it necessary to make the product out of this chemical (for example, arsenic in playground equipment).
– SAP member: A problem with identifying bad actors, there's an opportunity cost. Instead, work on identifying clearly better alternatives. Some safer approaches are nonchemical. I think it will take twenty years before parts per billion exposure hazards are known. This is not conventional toxicology. I think probably not more that 2,000 (probably more like 1,200-1,400) chemicals are causing most of the problems. We have alternatives for those. Looking for more data is a diversion of public effort. From my perspective, the Green Chemistry Initiative should look for that kind of data.

Dr. Warner thanked members of the public for their attendance and input.

<u>Review of the options drafted by the SAP subcommittees</u>

Dr. Warner introduced the list of ideas on the table and stressed that this is not a debate, but for clarification of the ideas on the table. The following fifty ideas were explored in a general discussion.

Institutional

1. Establish an independent non-profit institute to identify, develop and test safer alternatives.
2. Establish funding and support for CA Institutes for Green Chemistry and Engineering within the UC system.
3. Create public-private partnerships for Green Chemistry R&D
4. Establish Green Chemistry Innovation Centers

Educational

1. Train K-12 science educators in Green Chemistry
2. Develop Green Chemistry K-12 teaching materials
3. Develop Green Chemistry general education materials
4. Integrate Green Chemistry concepts into undergrad chemistry
5. Create Green Chemistry curriculum for business schools
6. Develop Green Chemistry fellowship and internships programs
7. Fund new Green Chemistry faculty lines
8. Develop Green Chemistry Technology transfer training

Information Generation

1. Authorize OEHHA to evaluate toxicity of emerging solvents and make recommendations on how to deal with them
2. Create a Chemical Map of California

Research/Technology

1. Advance science of Alternatives Assessment
2. Identify existing Green Chemistry science and technology efforts
3. Identify Green Chemistry research and technology gaps
4. Establish Green Chemistry research fund
5. Establish innovative R&D support policies for GC
6. Establish Green Chemistry patent assistance program
7. Develop Intellectual Property policy for Green Chemistry research
8. Establish Green Chemistry labs and test sites
9. Advance science of toxicity testing

Regulation

1. Require manufacturers and importers of chemicals to provide health, safety and use info as entry condition
2. Create legislation that phases-out use of chlorinated solvents in California.
3. Require all air districts to adopt regulations of the South Coast Air Quality Management District.
4. Phase out sale of aerosol cleaning products
5. State mandate that manufacturers provide list of all ingredients in their products. NGOs compile lists.
6. Require manufacturers and users of hazardous chemicals, and processes involving hazardous exposures, to submit an alternatives assessment, identifying “greener” alternatives.

7. Manufacturers and retailers of chemicals in California must provide hazard info about products to Cal/EPA

Incentives

1. Implement a management system for CA chemicals manufacturers
2. Establish awards program and financial incentives for green chemistry innovators.
3. Creates a top ten list of problem materials. Solicits proposals for alternative design.
4. Incorporate green chemistry criteria to state procurement processes
5. Establish mechanisms to promote, maintain and nurture Green Chemistry processes and products (i.e., tax incentives, subsidies, grants, low interest loans).
6. Provide marketing exposure for Green Chemistry processes and products thus educating consumers.
7. Screen Formulations for Purchasing
8. Establish Governor's award for Green Chemistry research, education and other appropriate categories
9. Create a Green Chemistry R&D business plan competition (seed grants)

Information Dissemination

1. Provide retailers with guides for green alternatives to toxic products to help them select better alternatives.
2. Create a uniform and transparent scorecard that informs producers and consumers which products are "green."
3. Value Chain Communications
4. Leverage Chemistry Evaluation Info
5. Provide information on Chemistry Evaluation Approaches
6. Create a web-based greener chemical marketplace
7. Develop a web portal for Green Chemistry solutions
8. Integrate Green Chemistry in State Technical Assistance Programs
9. Promote Green Chemistry through industry associations
10. Promote Green Chemistry in job/workforce training and vocational education
11. Adopt a policy to identify chemicals of concern

<u>SAP business:</u>

Discussion around the SAP's draft list:

– this is just an initial draft for discussion today. What will the public see next? Our mandate is one third of the GCI process. Ongoing dialog on the web, and more public comment phase.

– Will SAP come to an end? Or continue as oversight to DTSC's implementation of green chemistry?

Staff requested SAP members to submit travel reimbursement information by Friday, April 4, to Cathy Cooke.

Emerson: next steps for today.
There was a general discussion of how to synthesize the work completed to date. Issues such as compressing the options list to a more workable number, logical groupings for the specific options, supply versus demand side options, appropriate length and level of detail for the final report.

The Synthesis Subcommittee will meet next week to work on planning the final SAP work.

Additional discussion:
– Policy/science discussion
– Make sure that as we squeeze down the options that nothing is dropped
– Cancel the larger call on April 1? That should be an SC6 meeting.
– Can we establish more benchmarks?
– Friday 4/18: see what we have re: a draft.

In closing the meeting, DTSC Director Maureen Gorsen commended the SAP for its hard work.

<u>Adjournment</u>
The meeting was adjourned at 5:30 pm PST.

Attachment: Submitted Written Comments from Members of the Public

Rebecca Sutton, Environmental Working Group

Environmental Working Group is encouraged by the growing level of attention and energy surrounding the issue of green chemistry in California. We thank the Science Advisory Board for this opportunity to participate in the dialogue.

However, like many others in the environmental community, we are concerned that the outcome of this conversation may not be the substantive, pro-active reform that we need. Green chemistry reform based largely on voluntary actions, economic incentives, and other measures that are discretionary for chemical and consumer product manufacturers are inadequate to address the public health threat caused by the pervasive contamination of our bodies and our environment with industrial chemicals.

We face a daunting situation – a world contaminated by thousands of synthetic chemicals, the majority of which have reached the market without any requirement for safety testing. Our own research indicates that industrial pollution begins in the womb: The body of each infant born in California contains a unique mixture of perhaps hundreds of chemicals, most never having been tested for safety individually, let alone in combination. Increasing rates of breast and prostate cancer, diabetes, autism, and many other serious health conditions in industrialized countries suggest our chemical-intensive economy may play a significant role in the health and well-being of our population.

We have an exciting opportunity in this state to create the broad changes in chemical policy necessary to protect human health and the environment. California's history of innovation and leadership in related issues including air quality, sustainability, and renewable energy, will foster the means to seek substantive solutions for reform of chemical health protections. And our powerful economy will ensure that the steps we take will have far-reaching impacts.

California is in a unique position to lead the country towards meaningful advances in public health. We ask the Science Advisory Board to ensure that the proposals it develops do not rely solely on voluntary actions by industry, but instead encompass mandatory, enforceable safety standards.

Paul DeLeo, The Soap and Detergent Association

While the SAP is not designed as a consensus-based activity, SDA encourages the SAP to consider and advocate solutions that will have broad support. As an industry trade association, we believe there are a number of those opportunities. For example, SDA supports transparency with regard to chemical data such as complete publicly available hazard data sets for chemicals. SDA believes it is

appropriate to conduct a prioritization exercise and focus green chemistry and engineering resources on those chemicals of greatest concern.