California Green Chemistry Initiative

Final Report

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December 2008

State of California
Arnold Schwarzenegger, Governor

California Environmental Protection Agency
Linda Adams, Secretary

Foreword

By Linda S. Adams
Secretary for Environmental Protection

I am pleased to present the California Environmental Protection Agency's (Cal/EPA) Green Chemistry Initiative (GCI) policy recommendations for strengthening the protection of public health and our environment and moving toward a sustainable California. The GCI proposal presents a new way to look at chemicals in our society, unleashing the creativity and innovation of our scientists and engineers to design and discover the next generation of chemicals.

Policy Recommendations

The six recommendations developed through the California Green Chemistry Initiative constitute a far-reaching, market-driven strategy with an ambitious aim—the launch of a new chemicals framework and

Implementation

Governor Arnold Schwarzenegger demonstrated his leadership on green chemistry policy by signing ground-breaking laws that will put into place two of the six recommendations in this report. AB 1879 (Chapter 559, Statutes of 2008) by Assemblymembers Mike Feuer, Sam Blakeslee and Jared Huffman requires DTSC to adopt regulations by January 1, 2011 to identify and prioritize chemicals of concern, to evaluate alternatives, and to specify regulatory responses where chemicals of concern are found in products. SB 509 (Chapter 560, Statutes of 2008) by Senators Joe Simitian and Ron Calderon requires an online, public Toxics Information Clearinghouse to be created that includes science-based information on the toxicity and hazard traits of chemicals used in daily life.

A critical foundation for green chemistry policy has been established by the enactment of these important laws. We are ready to begin the considerable amount of work that is needed to implement these laws and develop the other meaningful recommendations in this GCI report.

Over the past several decades, the Cal/EPA BDOs and other state agencies have successfully implemented numerous programs intended to reduce pollution and impacts to humans associated with the manufacture and/or use of specific chemicals and industrial or consumer products. Some programs require businesses to address industrial waste and pollution during the product's manufacture. Other regulatory programs evaluate potential impacts on the environment and human health and develop mitigation measures to address those impacts before the product is approved for use in the state. Some of these existing foundational programs include the Pesticide Evaluation and Mitigation Programs at the Department of Pesticide Regulation; the Toxics in Products Program at the Air Resources Board; and many other existing, successful regulatory programs across state government.

I recognize the importance of these programs and environmental, human health and economic benefits associated with existing programs that advance the goals and objectives of green chemistry and the need to avoid duplication. Therefore, in implementing the recommendations, the Cal/EPA BDOs will focus on those products, and more specifically, the chemical ingredients within those products that currently are not subjected to environmental and human health analysis and mitigation prior to their introduction into the marketplace. Products and chemical ingredients that are the subject of such existing scrutiny are not intended to fall under the purview of the GCI.

I will establish an external economic and technology advisory group, similar to the Economic and Technology Advancement Advisory Committee (ETAAC) formed under the California Global Warming Solutions Act of 2006. Like ETAAC, I would like to see this group advise me on activities that will facilitate investment in technological research and development and funding opportunities.

Education is vital to advancing California's well-being and, as highlighted by this report, is a cornerstone to developing a green chemistry workforce. I would like to seek the assistance of leaders from California's postsecondary institutions to integrate green chemistry principles into the curricula for chemistry, engineering, environmental science, and other disciplines. By working together, we can prepare our future workforce to meet the public's demand for safer, less toxic consumer products. This report complements the newly enacted, California Green Collar Jobs Act of 2008 (AB 3018, Chapter 312, Statutes of 2008) by Speaker Emeritus Fabian Nuñez. This law requires the California Workforce Investment Board (CWIB) to establish the Green Collar Jobs Council to develop programs, strategies and resources that promote workforce training and job opportunities in California's emerging green economy. I look forward to partnering with the CWIB to develop green collar jobs for California.

California is not only a national leader in environmental programs, but an international leader as well. Green chemistry is integral to a chemically safer global economy. Therefore, building upon our successful international partnerships on climate change, I intend to engage other nations in our GCI efforts through agreements or memoranda of understanding. The establishment of a toxics clearinghouse is a key example of a GCI outcome that will be mutually beneficial.

The California Green Chemistry Initiative builds on Governor Schwarzenegger's leadership in environmental protection, climate change and natural resource preservation. Under his leadership, we can establish the six recommendations as official policy for the State of California and continue building the framework for a sustainable California.

DEPARTMENT OF TOXIC SUBSTANCES CONTROL
MAUREEN F. GORSEN, DIRECTOR
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Linda S. Adams
Secretary for Environmental Protection
Office of the Secretary
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Dear Secretary Adams,

I am pleased to transmit to you the final report of the California Green Chemistry Initiative. The report recommends six policy strategies which will strengthen the protection of public health and our environment and move toward a sustainable California.

Last year, you called upon us to develop a comprehensive approach for assessing potential hazards from chemicals in consumer goods and products. The Department of Toxic Substances Control (DTSC) collaborated with other state agencies and departments to gather input from experts and stakeholders worldwide. During this initiative, more than 57,000 comments and 800 options were received. We have distilled this input into six policy recommendations.

Green Chemistry is a systematic scientific and engineering approach that seeks to reduce the use of hazardous chemicals and the generation of toxic wastes by changing how society designs, manufactures, and uses chemicals in processes and products. Rather than managing wastes after end-of-product life (or "cradle to grave"), Green Chemistry shifts our focus to designing chemicals, processes, and goods that have less or no adverse effects—throughout their lifecycle ("cradle to cradle")—on California's people and our environment. Stakeholders told us that this new green chemistry approach offers substantial opportunity for the state—through better information; innovation and new technology; new high-skill, high-wage jobs; stronger worker and consumer protection; and a cleaner, healthier environment. They further told us that the Schwarzenegger Administration and California are uniquely and well positioned to realize these opportunities.

As a state, the most important thing we can do is give all our children the chance to fulfill their dreams, achieve their potential, and work together in productive and sustainable jobs and communities. The six recommendations in the attached report reflect this obligation. The report sets forth new ideas to protect our children's health from toxic chemicals in products; enhance the education and training they will need; offer them more opportunity and better choices in a burgeoning global market; and, build their capacity to create a clean, green California for present and future generations. The California Green Chemistry Initiative builds on Governor Schwarzenegger's leadership in environmental protection, climate change and natural resource preservation.

Under your direction, we can establish the attached six recommended actions as official policy for the State of California and work with the Legislature to establish the framework for a sustainable California.

Sincerely,

Maureen Gorsen, Director
Department of Toxic Substances Control

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California Green Chemistry Initiative
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1. Executive Summary

Why Green Chemistry?

Green chemistry represents a major paradigm shift that focuses on environmental protection at the design stage of product and manufacturing processes. It is an innovative way to deal with chemicals before they become hazards, with the goal of making chemicals and products "benign by design." Green chemistry is a preemptive strategy that reduces the use of toxic substances before they contaminate the environment and our bodies. It is a marked departure from the past where society managed industrial and municipal wastes by disposal or incineration. Green chemistry seeks to dramatically reduce the toxicity of chemicals in the first place, rather than merely manage their toxic waste after use and disposal.

Green chemistry focuses on improving the building blocks of manufacturing—the feedstocks and the catalysts used to make things—so products can be engineered to be safer, easily reused and not persist in the environment. The use of fewer hazardous substances means healthier air quality, cleaner drinking water and a safer workplace. Green chemistry changes the design of products and industrial processes so they do not threaten human health or the environment.

Green Chemistry is...
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.

Anastas and Warner
Green Chemistry: Theory and Practice (1998)

For example, "green chemists" are presently working on road and construction materials that sequester carbon dioxide while simultaneously making those materials harder and more durable over time. Green chemists are developing lighting that contains no mercury or other toxic materials and is 50 times more energy efficient than the fluorescent light bulb. Solar cells are being developed at the nano-scale that can become ingredients in paints, coatings and clothing. This innovation will help advance distributed energy generation. Green chemists are also developing substances and materials for everyday consumer products that contain less toxic ingredients and are based on lifecycle thinking and cradle-to-cradle design which avoids costly waste management and regulatory regimes.

Every week, headlines reveal consumer products with suspected toxic substances. There are tens of thousands of chemicals in use today, but we know very little about how they affect people or the environment. This information gap prevents the free market from working properly to stimulate the innovation of safer, healthier substitutes.

Consumers are not the only ones who lack information about ingredients and their effects. Businesses along the supply chain also lack this basic information, which could lower the costs and liability arising from goods that contain toxic substances.

Large, desirable markets in India and the European Union are demanding less toxic products. California has the opportunity to lead the nation in creating the safer substitutes that these global markets will continue to demand in the coming decades. California also does not want to become a dumping ground for toxic products prohibited elsewhere.

Chemistry has fueled remarkable medical, agricultural and industrial advances over the past half century and has improved every facet of life. The chemical industry estimates it contributes $635 billion to the nation's gross domestic product (GDP). Green chemistry is an opportunity to spur the next industrial revolution through human ingenuity and creativity. Advancing green chemistry is an opportunity to make a safer and more efficient world with less waste. California can lead with a green chemistry program to harness the power of the market, unleash innovation to increase competitiveness and build better products.

Although California has made tremendous progress in cleaning up its air, water and land over the last 40 years, existing laws and regulations focus primarily on the pollutants generated from a cradle-to-grave industrial system (what we throw out as a society). Today we confront new challenges from toxics in the consumer goods and products we use and discard daily. These challenges include:

- Uncertainty about the safety of chemicals in products which are manufactured around the world
- Little or no information about chemical ingredients and potential hazards
- Poorly conceived actions like bans that do not consider alternatives and often create new problems when substitutions are made
- Billions of dollars in state taxpayer costs for long-term stewardship of a burgeoning hazardous waste stream

cosmetics. In September 2006, he signed landmark biomonitoring legislation that makes California the first state to measure and catalogue human exposure to chemicals.

In April 2007, Linda Adams, Secretary for Environmental Protection, launched the California Green Chemistry Initiative in collaboration with California Environmental Protection Agency (Cal/EPA) boards, departments and offices, as well as other state agencies. The Secretary asked the Department of Toxic Substances Control (DTSC) to lead the initiative and conduct a broad public process to generate ideas, develop overall policy goals and make recommendations. In signing AB 1108 (Chapter 672, Statutes of 2007) to ban phthalates in toys, Governor Schwarzenegger reaffirmed that "[a] comprehensive and unified approach [to chemicals] is needed to ensure good accountable policy." This report provides the results of that process and makes specific recommendations for implementing a comprehensive green chemistry policy framework in California.

> **"I am looking forward to the recommendations being developed as part of the Green Chemistry Initiative led by my Secretary for Environmental Protection. I encourage the Legislature and all California stakeholders to participate in this important initiative so that we can develop policies that will again allow California to lead the nation and the world in health and environmental protection."**
>
> *Governor Arnold Schwarzenegger October 2007*

The six policy recommendations in this report build upon present environmental protection laws, shift the focus from end-of-pipe cleanup to up-front design and prevention, foster innovation and prompt market changes toward a sustainable economy. They include:

- **Expand Pollution Prevention** to assist California businesses to lead the world in greener design and production
- **Develop Green Chemistry Workforce Education and Training, Research and Development, and Technology Transfer** to meet global demand for greener materials and products
- **Create an Online Product Ingredient Network** to disclose chemical ingredients in products sold in the state to allow consumers and businesses to make safer choices
- **Create an Online Toxics Clearinghouse** to increase our knowledge about toxicity and hazards for chemicals
- **Accelerate the Quest for Safer Products** to make the transition to more sustainable, safer products more quickly using science-based alternative analysis and lifecycle thinking
- **Move Toward a Cradle-to-Cradle Economy** to leverage market forces to produce products that are "benign-by-design"

These policy recommendations build the capacity in the future workforce and in businesses for green chemistry innovation and economic growth. They provide the information (on ingredient data and toxicity data) needed to identify opportunities and select safer materials in products. They provide the tools and metrics to make the transition to safer, more sustainable products.

As our population grows and our economy expands, more chemicals will be used, more products will be consumed and more wastes will be generated. California must move toward a more sustainable economy. Green chemistry and lifecycle approaches will accelerate this necessary transition, promote development of clean and green technology, reduce our consumption of energy and natural resources, create high-skill, high-wage employment and increase California's competitiveness in the global arena of innovative green technology.

The California Green Chemistry Initiative is an opportunity to accelerate technological innovation in materials science. It can catalyze research at California universities. It can help create the solutions needed to curb global warming and meet the goal of a 30% reduction in greenhouse gas emissions by 2020. Consumers would be protected against adverse effects of toxic substances in the products they use. Less floating non-biodegradable debris would help marine life and make our beaches cleaner. Fewer landfills and hazardous waste sites would be passed on to future generations.

"The six recommendations developed through the California Green Chemistry Initiative constitute a far-reaching, market-driven strategy with an ambitious aim—the launch of a new chemicals framework and a quantum shift in environmental protection."

Linda S. Adams, Secretary for Environmental Protection

II. The Initiative Process: A Year of Exploration, Study and Collaboration

Science Advisory Panel

II. The Initiative Process: A Year of Exploration, Study and Collaboration

In response to Cal/EPA Secretary Adams' directive in 2007, DTSC Director Maureen Gorsen launched the California Green Chemistry Initiative. DTSC, with other state agencies, boards and departments, organized teams for the initiative, hosted an extensive, innovative public process, created a Scientific Advisory Panel and oversaw the work of key element teams. DTSC conducted this monumental, year-long effort in two phases. This Final Report culminates that process and makes six recommendations for a new chemicals policy framework for California.

The goal of the California Green Chemistry Initiative was to develop policy recommendations to stimulate "green" design of products so that the manufacturing, use or disposal of products generates, uses and releases less hazardous chemical substances.

To provide leadership and guidance to this initiative, DTSC formed the Green Chemistry Leadership Council. The Council included the chief executives of the Cal/EPA boards, departments and offices; the Department of Public Health; the Department of Conservation; the Department of Homeland Security; the Department of General Services; the California Occupational Safety and Health Administration (Cal/OSHA); and, other state agencies and departments.

During Phase One, which began in April 2007, DTSC and collaborating departments:

- Sponsored scientific symposia
- Invited experts from around the world to discuss green chemistry options
- Facilitated stakeholder workshops around the state to solicit the best thinking from industry, community groups, environmental organizations, academia and the public
- Hosted an online blog, "A Conversation with California," that generated 57,000 web hits and 818 potential policy options

DTSC compiled all that was learned in the first phase and, in January 2008, submitted the information to Secretary Adams in a "Phase One Options Report" (see Appendix A).

During Phase Two, beginning January 2008, DTSC culled, compiled and synthesized the leading options from what had been learned in Phase One. Continuing to seek out the best policy thinking, DTSC, participating state agencies and stakeholders explored how leading options might be implemented, by whom, in what way and how those actions might be funded. The department organized three distinct "tracks" to analyze the potential options. These tracks were:

Track 1: Public workshops, discussion forums, consultations and web-based input
Track 2: Science Advisory Panel
Track 3: Key Element Teams

Public Workshops and Forums

The first track included interactive focus group meetings, public presentations and public workshops around the state where options were discussed and explored in more detail. Stakeholders included environmental

groups, health organizations, manufacturers, industry associations, government, academia and others. After each meeting, the nature of the options and the framework were revised to reflect the input. The recommended framework represents an iteration of efforts that considered, sorted, aligned, summarized and integrated stakeholder input. Appendix C organizes the options presented in both phases, by each policy recommendation.

During this track, stakeholders helped develop the following goal and objectives:

Goal:

California is a leader in the innovation, manufacture and use of safer, more environmentally benign products and processes and in the protection of public health and the environment from toxic harm.

Objectives:

1. Reduce the presence of hazardous substances in products and processes.
2. Drive technological innovation and development of safer, healthier, more environmentally benign products and processes across their lifecycles.
3. Train a new generation of chemists, engineers and knowledgeable workers who will develop and produce safer products.
4. Motivate and support new investments in more benign chemistries, products and processes.
5. Move from a system where materials are on a one-way trip from the cradle to the grave to a system where materials are recovered for reuse in new products and processes, with reduced potential for harming human health and the environment.
6. Stimulate consumer demand for greener products through improved information.

Science Advisory Panel

A second track was the Science Advisory Panel, consisting of leading experts on green chemistry, green engineering, technological innovation and regulatory policy from around the country. These experts met extensively and, through teamwork, arrived at a final collection of 38 options for DTSC Director Gorsen in May 2008. Thirty-five of the options are consistent with the six policy recommendations. The other three were not included. The Science Advisory Panel report is presented in Appendix B.

Science Advisory Panel

Key Element Teams

In the third track, representatives of state agencies and departments explored, developed and drafted proposed initial plans to align related existing state governmental programs with the overall objectives of the California Green Chemistry Initiative.

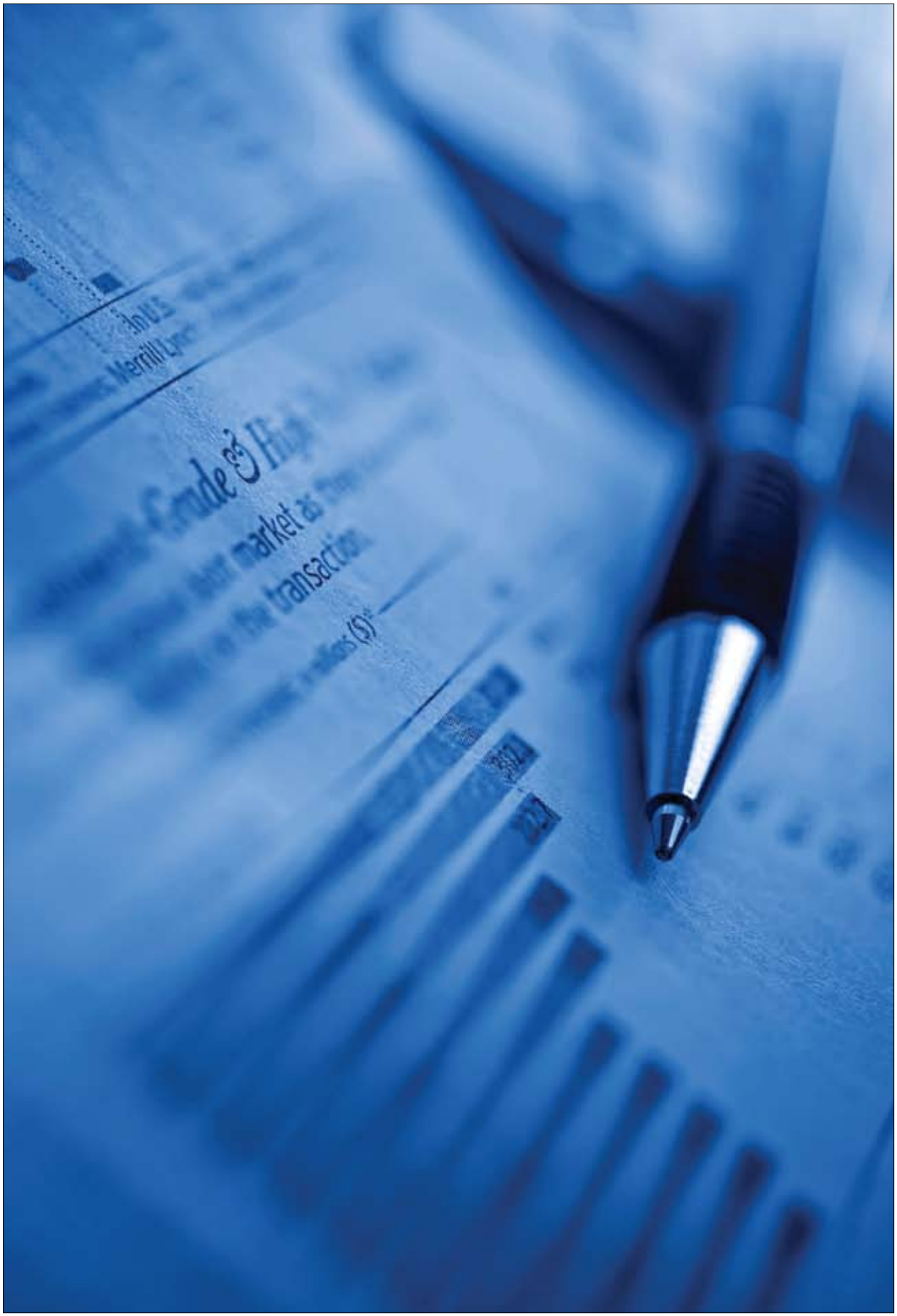
These "key element teams" developed initial plans for:

- Disseminating information on toxic chemicals; empowering consumers to make informed choices; and forging strategic partnerships
- Strengthening consumer protection laws
- Expanding California's pollution prevention program
- Training a new generation of scientists and engineers
- Including green chemistry principles in Cal/EPA's Education and the Environment Initiative (EEI)
- Accounting for chemical toxicity and impacts in state and local government procurement decisions

The key element team reports and initial plans are compiled in Appendix D.

Phase Two Workshop, Sacramento, California

III. Policy Recommendations



III. Policy Recommendations

From the year-long process of compiling, discussing and analyzing the multitude of ideas presented, six major policy recommendations were developed. Each recommendation is a synthesis of the comments, ideas and suggestions from the many experts and stakeholders who participated in the initiative. The description of each policy recommendation begins with the overall vision that will result from the described policy actions. To help understand how each of the recommendations will work conceptually, the steps associated with the policy actions are included along with the basis and rationale. An overview of funding options, compliance options and brief information about related activities in other states and governments also helps with envisioning the policy concepts. Rounding out the discussion of each policy recommendation, suggested metrics are provided to gauge, monitor and adjust the progress of the recommended activities as they are implemented.

The funding section under each recommendation outlines possible approaches in concept only. As policy makers consider each policy action further, they will decide how and in what way the recommended action will be implemented in more detail. After those details evolve in the next phase of the initiative, the associated costs, savings, benefits and appropriate funding options can be better determined and evaluated. At a minimum, these future discussions must include development of a funding structure to support the state's responsibilities in program implementation.

The six major policy recommendations are described in the following pages.

Policy Recommendation One

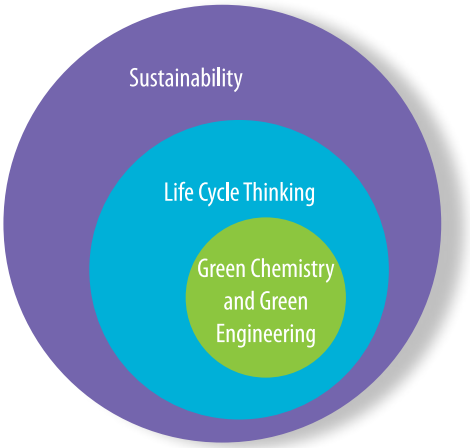
Expand Pollution Prevention

Vision: An expanded and modernized DTSC Pollution Prevention (P2) Program helps California's businesses become leaders in green chemistry and engineering and use "lifecycle thinking" to reduce the environmental footprint of their facilities, manufactured products and services.

Lifecycle thinking, also called lifecycle approaches or lifecycle management, is the application of lifecycle principles to business practices. **Lifecycle thinking** involves examining the environmental sustainability over the product's entire life – from raw materials selection, manufacturing, transportation, use and end of life disposal or reuse and waste management. Tools, metrics and approaches using lifecycle thinking are often used to determine a product's "environmental footprint."

Improved pollution prevention at participating California facilities protects neighboring communities from public health impacts, protects the environment and improves worker and consumer safety (for examples see illustration on page 16). California businesses that adopt green practices enhance revenue with increased consumer demand for cleaner products and substantially reduce costs through more efficient resource use, reduced energy consumption, reduced liability and insurance payments, reduced regulatory burdens and reduced hazardous waste management costs.

Figure 1. Green Chemistry: An Essential Component of Sustainable Production. *Both green chemistry and green engineering rely upon lifecycle thinking to bring their concepts to fruition. All three serve to achieve the ultimate goal of a sustainable economy and society. Source: California Green Chemistry Initiative Science Advisory Panel Report, May 2008.*



Expansion of DTSC's pollution prevention program should include:

- Increasing the scale to assist specific small and large business sectors in reducing chemical hazards
- Bolstering the capacity of local Green Business Programs to serve all small and medium size businesses statewide, in all business sectors
- Increasing investment in the development of safer alternatives to toxic chemicals and offer incentives to help overcome cost and performance barriers that prevent some businesses from going green

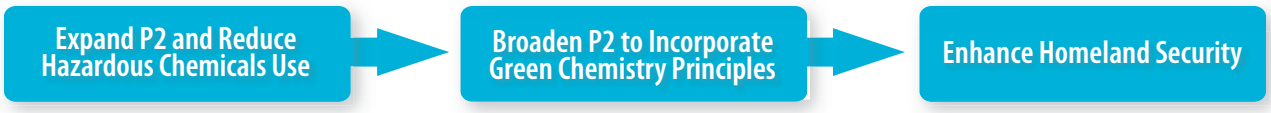
Modernization of DTSC's pollution prevention program should include:

- Broadening the program to incorporate a green chemistry and engineering design approach in evaluating the comparative environmental and energy impacts of different chemicals and processes, as opposed to the current focus on end-of-pipe hazardous waste generation.

Lastly, improvement of DTSC's pollution prevention planning at California facilities should include:

- Adding a new dimension to California's Accidental Release Program (Cal/ARP) which works to prevent accidental release of regulated substances. By adding a pollution prevention planning component, the Cal/ARP program can increase its effectiveness for emergency response preparedness. By adding green chemistry and engineering capabilities, the Cal/ARP program can reduce the risks of use and storage of hazardous chemicals and thereby reduce the risk of catastrophic loss of life. Emergency responders, workers and the neighboring community would be safer in the event of a natural disaster, accidental release, or act of terrorism at a chemical-using facility subject to the Cal/ARP program.

Figure 2. Expand Pollution Prevention (P2)



Description: For nearly two decades, industry sectors such as vehicle service and repair shops, auto body and paint shops, and hospitals have partnered with DTSC to implement pollution prevention measures that reduce the potential for hazardous waste generation. In doing so, these businesses have decreased toxic risks to California's people and the environment, and also have saved money.

Extensive experience gained in the DTSC pollution prevention program across multiple business sectors has demonstrated that program effectiveness can be increased if the state:

- Revises state law governing DTSC's source reduction program to include lifecycle and green engineering processes (such as chemical input substitution) rather than focusing only on hazardous waste generation and disposal

- Enhances support for local green business programs to create a statewide network with sufficient capacity to recognize and reward all businesses meeting program criteria
- Makes state government a pollution prevention leader by adopting environmentally preferred technologies and practices (supplementing the state's green product procurement efforts) to guarantee a market for green technologies
- Develops and evaluates data on the extent of voluntary adoption of pollution prevention measures to drive regulatory priorities
- Enhances designated state agencies' roles in prevention planning through the Cal/ARP program, to enhance public safety in the event of a catastrophic accident

How: Expand the existing DTSC pollution prevention program to maximize participation and environmental benefit. More specifically, engage stakeholders and policy makers to: add green chemistry and green engineering principles to the existing hazardous waste reduction elements; provide technical assistance to businesses that implement green chemistry; invest in safer green chemistry processes and technologies; and, assist small businesses with cost barriers to move toward becoming a green business. Pursue program changes to develop and disseminate information on safer alternatives which will encourage wider adoption. Work with the Certified Unified Program Agencies and policy makers to identify chemical substitutions and process changes that reduce the potential for catastrophic impacts from accidental releases at Cal/ARP facilities. Please see the Pollution Prevention Key Element Team Report in Appendix D-3 for a detailed discussion of how these program enhancements could be implemented.

POLLUTION PREVENTION CASE STUDIES: The Environment and the Economy Win!

Auto Repair Shops

A voluntary pollution prevention partnership between DTSC and auto repair shops from 2000 through 2008 resulted in the following environmental gains:

- 800 lbs of hazardous waste reduced
- 19 tons of wastewater runoff eliminated
- $9,000 annual costs savings per auto repair shop

One hundred and fifty auto repair shops participated in the voluntary program. If all 30,000 auto repair shops participated in the program, California could reduce the amount of hazardous waste generated by 630 tons and provide a savings of $230 million for the industry statewide.

Hospitals

In a voluntary pollution prevention partnership with hospitals to eliminate mercury – a toxic metal – used in hospital equipment, California led the nation in reducing toxic mercury risks at hospitals. Fifty percent of the nation's reductions in mercury occurred in California. From 2002 through 2005, seventy-nine hospitals received a HELP (mercury Hospital Elimination Leadership Program) for removing two tons of mercury from its hospitals, avoiding the health risks, tort liability and costly waste management.

Why: The existing DTSC pollution prevention and source reduction program is effective but limited to a small number of industrial sectors (only two every two years) and only to those California facilities within each sector which are subject to hazardous waste source reduction planning requirements. There are far greater numbers of businesses that could see triple bottom line profits (see Figure 3, page 17) and would volunteer to participate in a broader DTSC pollution prevention program. With the recommended program changes, more businesses can participate. They will implement green chemistry approaches, develop safer alternative inputs and processes, and share best practices with more industry sectors. These increased efforts will help ensure the success of local green businesses and enhance public health and environmental quality.

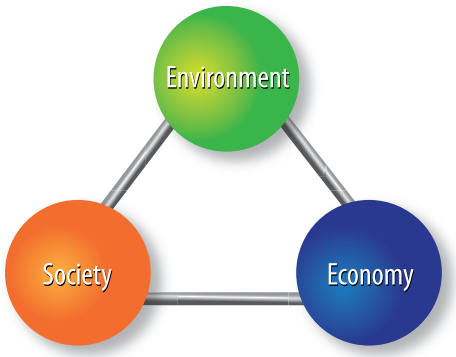


Figure 3. Triple Bottom Line. *When economic, social and environmental bene ts are integrated and balanced, sustainability can be maintained. Some businesses refer to this goal as the triple bottom line.*

Funding: Like the existing DTSC pollution prevention program, state government costs could be supported from fee-based special funds. State government could approach specific industry sectors to co-fund alternatives research with broader application to the sector as another funding option. Grants and loans can help businesses overcome cost barriers to new, better technologies. For example, the Carl Moyer Memorial Air Quality Standards Attainment Program (Carl Moyer Program) provides grant funding to encourage the voluntary purchase of cleaner-than-required engines, equipment and emission reduction technologies. Since 1998, the State Air Resources Board (ARB) has distributed state bond and fee-based funds to participating air pollution control/air quality management districts for specific clean air projects in the local districts. This program now funds $141 million in statewide emission reduction projects annually. A similar financial assistance program could be developed to assist California businesses in implementing cleaner, green chemistry technologies and achieving environmental quality and public health benefits.

Other States and Governments: Massachusetts and several other states have programs to reduce the use of toxic substances or minimize hazardous waste generation. Many of these state-based programs collaborate with academic and research institutions. Several are operated in conjunction with the respective state's economic development programs.

Metrics: Progress toward reductions in toxic substance use and life safety hazards at facilities in California could be measured by:

- Industry cost savings through design and process changes that reduce toxics use and hazardous waste generation
- The number of facilities and industrial sectors participating in an expanded DTSC pollution prevention program
- Reduction in the volume of toxic chemicals used at facilities in California
- Reductions in the environmental footprint of facilities

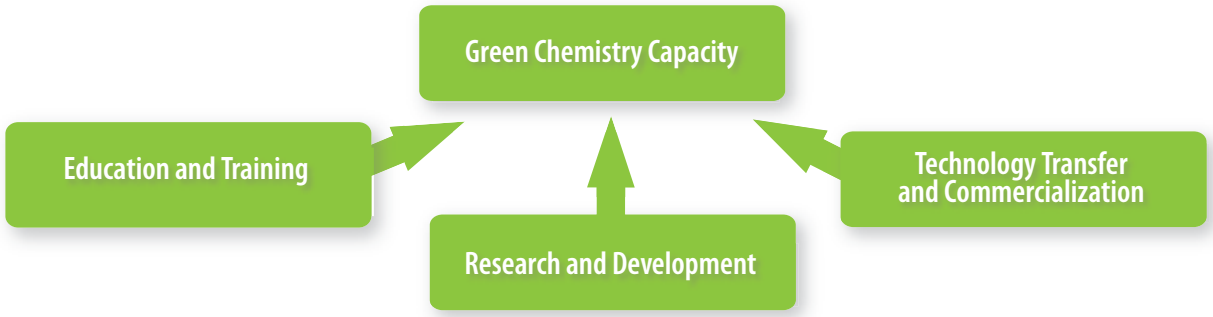
Compliance: Participation in the expanded and enhanced DTSC pollution prevention program would be voluntary. To encourage broader voluntary participation, various incentives, such as grants, loans, relief from certain regulatory reporting, or fee reductions should be considered.

Policy Recommendation Two

Develop Green Chemistry Workforce Education and Training, Research and Development, and Technology Transfer

Vision: California positions itself as a global leader for new ideas, green technologies and industries and a well-informed workforce through green chemistry and green engineering curriculum in primary and secondary schools, community colleges, career technical education, universities and research institutions. Californians lead the world in inventing, developing and commercializing new green chemistry engineering and materials science processes and products. Our next generation of scientists, engineers and consumers are the "knowledge capital" for new and expanded global markets. California exports its green chemistry-driven innovations and supplies safer, greener products to the world.

Figure 4. Develop Green Chemistry Workforce Education and Training, Research and Development, and Technology Transfer



Description: As the Science Advisory Panel and others strongly recommended, California should build green chemistry capacity through specific actions: (a) in primary, secondary and higher education, (b) in research and development, and (c) in technology transfer and commercialization.

Educational curriculum, teaching materials and instructor training should incorporate green chemistry concepts for California's primary, secondary and career technical education schools, colleges and universities and research institutions. Research and development in new green materials and product design should be increased. The state should improve technology transfer and commercialization so California's green innovations fuel economic growth.

To do so, California should:

- Through education, cultivate an understanding of basic principles of chemistry, environmental sciences, toxicology and sustainability
- Foster interest in careers in science, chemistry, engineering and other related disciplines
- Develop career technical training programs—through community colleges and trade schools—to train green laboratory and green manufacturing technicians
- Build, through academic teaching at institutions of higher learning, a workforce equipped with the scope and breadth of knowledge and skills to advance green chemistry and an intellectual environment that catalyzes the development of new ideas and technological innovations
- Establish multidisciplinary opportunities for students, international exchange programs for students and professionals, scholarships, internships and fellowships in green chemistry

- Stimulate innovation of product and technology development through public-private collaborations, including California's colleges, universities and national laboratories
- Establish research grants, financial incentives, intellectual property assistance and challenge programs to develop and commercialize green chemistry technologies and processes
- Develop a well-informed citizenry capable of actively engaging in demanding and supporting green products and processes and avoiding unsafe chemical use and disposal practices

More detailed descriptions of the specific actions to integrate green chemistry and engineering into the educational curriculum are included in Science Advisory Panel's report in Appendix B and the Education and the Environment Initiative Key Element Team report in Appendix D-5. The specific actions for career technical training are described in Train the New Workforce Key Element Team report in Appendix D-4.

How: California can increase green chemistry capacity in education and training, in research and development, and in technology commercialization and transfer.

Through California's landmark Education and the Environment Initiative (EEI) program, green chemistry principles can be incorporated into the state's curriculum and teaching materials now being developed for primary and secondary schools.

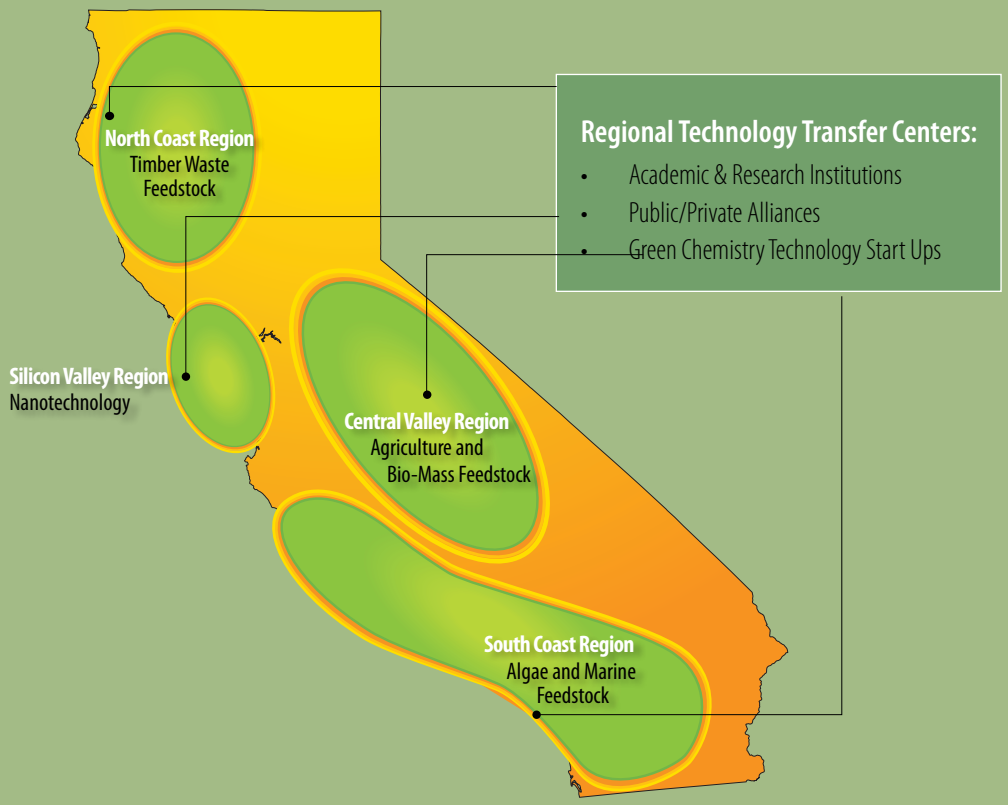
California's **Education and the Environment Initiative (EEI)** is the first program of its kind in the nation. EEI integrates environmental themes—such as climate change, air and water pollution and human effects on natural systems—into the state's academic curriculum. While learning science, mathematics and language arts, school children from kindergarten to high school develop environmental literacy. The **EEI program** partners with the state's education leaders, environmental regulators, Heal the Bay and the National Geographic Society in this innovative effort.

Green engineering is the design, commercialization and use of processes and products which are feasible and economical, minimize the generation of pollution and reduce risk to human health and the environment.

California's colleges and universities can align their curriculum and teaching with green chemistry and green engineering principles. The state's university systems—the California State University (CSU) and the University of California (UC)—can re-evaluate accreditation and degree requirements to ensure that students in chemistry, engineering, environmental science and other disciplines have coursework involving green chemistry principles. College students can learn green chemistry through new course curriculum, multidisciplinary studies, exchange programs, internships and research fellowships. When hiring new faculty in science, engineering, business and other academic positions, the state's colleges and universities can expand academic qualifications to include knowledge, skills and research in green chemistry.

California Golden Opportunity in Green Chemistry

Incubators of Green Chemistry Technology Transfer



Technology Transfer Centers (Incubators)

Technology transfer centers—or incubators—could be established to develop green chemistry products using new feedstocks. For example, products that currently are made from chemicals that persist in the environment, such as plastic bags and bottles, could be made from agricultural wastes, timber and wood wastes. New incubators could be established in the respective regions of the state to transform the bench-scale ideas into commercial applications and new clean green industry growth sectors.

Expanding career technical training is crucial so California can increase the number of technicians, laboratory workers and skilled post-secondary graduates who are needed in the burgeoning green materials, clean technology, nanotechnology, and related fields. (See Appendix D-4 for more detailed information about developing the technical workforce for green chemistry.)

As California firms adopt green chemistry applications or start new ventures based on green chemistry solutions, trained workers are needed to operate these new production systems and technologies. Along with community colleges, community-based training programs have successfully equipped workers for high-skill jobs in information technology, biotechnology and similar fields. These programs can help prepare California's new green chemistry workforce.

Science and technology are at the heart of green chemistry and green engineering. California has natural advantages historically in "bootstrapping" research into new entrepreneurial ventures. For green chemistry, scientific research, technology development and commercialization, and technology transfer have tremendous potential to build a strong, healthy economy and state.

For example, additional tools are needed to generate chemical hazard and toxicological information. Scientists said that the development of analytical and laboratory tools for quantitative structural activity relationship (QSAR) analysis, high through-put methods and read-across methods will increase our ability to make better informed comparisons of chemicals when designing new products or evaluating existing ones. More investment through industry/university partnerships, challenge grants for targeted research, direct grants for green chemistry science and technology, patent and intellectual property assistance and similar actions can catalyze this economic growth. (For a more detailed discussion, see the Science Advisory Panel report in Appendix B). Additionally California can establish technology transfer centers—or incubators—for rapid commercialization of green chemistry solutions.

"Advances in sustainable agriculture, medical and industrial processes are emerging all around us. This initiative by the Schwarzenegger Administration is aimed at embracing the science of our time and blending it with innovations to expand the greening of our nation and world. As a result of this convergence, California agriculture is uniquely positioned to participate in this exciting new green chemistry economy."

A. G. Kawamura, Secretary of the California Department of Food and Agriculture

Why: Increase California's capacity to develop an educated, trained workforce; conduct green chemistry research and develop new ideas; and commercialize those ideas to offer substantial gains for the state's economy and environmental quality.

Education is vital in advancing California's environmental, economic, social and cultural well-being. Primary and secondary education gives students the basic knowledge and skills to prepare for technical training, higher education and employment. Adding green chemistry to this curriculum through the EEI program fosters interest in technical fields and develops a well-informed society.

The Community College System and career technical education also are vital in training a new generation of "green collar" workers. The scientific and technical workforce needed for the global green chemistry economy requires highly-skilled technicians, laboratory workers and other employees who can apply green chemistry principles in their jobs.

The California university systems and, in particular, the university-operated national laboratories, are a focal point for new research and technology development. Increased collaboration between academia, government and industry will enhance the exchange of new ideas and emerging technologies, offset research and development costs and train a new generation of specialized workers. These partnerships could expedite the development and commercialization of new, environmentally preferable technologies. It will create a new green sector—clean technology—for green materials inventors, designers and manufacturers. It will also help create, attract and fill new high-skill, high-wage jobs—boosting California's economy. Additional investment in research, development and commercialization of green chemistry solutions is crucial to restore California as a leader in technology and innovation-driven economic growth. Together, building green chemistry capacity in education, training, research, development and commercialization will create new global market opportunities for California businesses.

Figure 5. Cleantech Venture Capital Investment by Sector in the U.S. ($ million). *While energy and renewable technology companies receive the lion's share of venture capital investment, green chemistries, including materials science and nanotechnology, when combined garnered the second largest share (see green chemistry light green combined bar).*

At the Florida Climate Change Summit in June 2008, Governor Schwarzenegger hailed the coming of "California's new Gold Rush, because billions of dollars in clean technology investment are flowing into our state." In 2007, the clean technology sector grew to $3.5 billion nationally.[2] This investment equates to 48,000 new direct jobs and additional revenues of $10.8 billion. While energy and renewable technology companies received the lion's share of that investment, green chemistries, including materials science and nanotechnology, garnered the second largest share. California can do more to create the capacity in its workforce and educational system to include a green chemistry and materials science infrastructure. And, California can capture a greater share of the growing global market for green materials and technologies.

The Milken Institute[1] recently ranked California fourth among the 50 states in generating economic growth from technological and scientific innovation, behind Massachusetts, Maryland and Colorado. By embracing policies that stimulate green chemistry, California can regain its position as a leader of technological innovation and economic growth by developing new clean materials and safer substitutes for consumer products. Worldwide, chemical usage is increasing every year as markets grow and demand increases (see Figure 6). California can be a leader in providing green chemistry technologies and products for the burgeoning chemicals and materials sector.

Figure 6. Global Chemical Production *is expected to double every 25 years, even as global population increases at a much slower rate. Source: American Chemistry Council (ACC)*

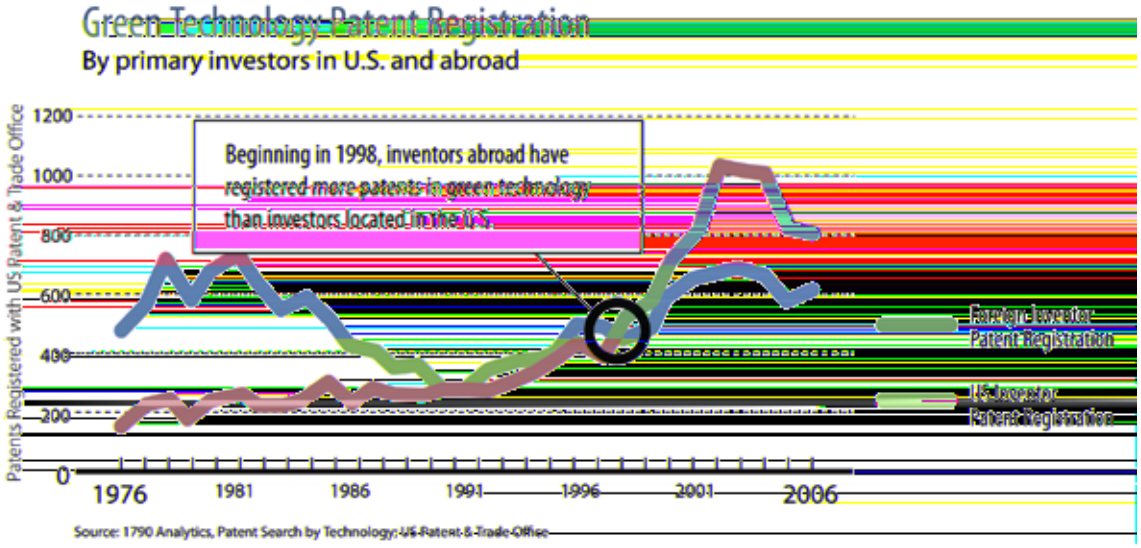
[1] The Milken Institute is an independent economic think tank whose mission is to improve the lives and economic conditions of people in the U.S. and worldwide by focusing on human, financial and social capital. http://www.milkeninstitute.org/

[2] Cleantech Venture Network: Price Waterhouse Coopers

Funding: Additional investment is needed to expand education, increase research and development, and accelerate technology transfer for green chemistry principles, processes and new products. Traditionally, the public university systems in California derive funding from state government revenues (fees and bonds). Increasingly, the public pension funds and private capital (venture capital and equity capital (see Figure 5, page 22)) have provided additional resources for public/private partnerships aimed at developing and marketing environmentally sustainable practices and goods. Both funding models could be adjusted to make existing financing available for green chemistry research and development.

The establishment of a network of research and development centers (or incubators) for green chemistry purposes could also receive other governmental funding. The research and development portions of the appropriations to the U.S. Departments of Energy, Defense, Health and Human Services and Agriculture would be relevant linkages for funding to increase green chemistry capacity in California and the nation.

Figure 7. Green Technology Patent Registration. *Since 1998 registration of green technology patents from inventors abroad have outpaced registration of patents from inventors located in the U.S.*



Re-aligning and increasing the existing governmental funds that support education, research, and technical transfer would require adjusting fees, tax incentives, credits, and financial aspects of jointly-funded intellectual property. Various bond mechanisms could also be applied for building green chemistry infrastructure. More information about various funding mechanisms is also presented in the Phase One Report; see Appendix A.

Other States and Governments: California has much to learn from other nations and states in this area. India has invested considerably in public-private green chemistry education programs in several universities and research institutions. Other developing nations are following with initial steps that are intended to position graduates and emerging businesses in the huge global chemicals market. Figure 7 (above) illustrates gains abroad in patents for new green technologies.

Several U.S. universities and institutions, including the Warner Babcock Institute for Green Chemistry in Woburn, Massachusetts, Yale University, Carnegie Mellon University, University of Oregon and Arkansas State University have created centers and academic programs emphasizing green chemistry. To date, the University of California and California State University systems have only a fragmented collection of programs and projects that include green chemistry concepts.

California's EEI program—for K-12 school children—is unique. While no other state has a similar statutory program directly integrated with its academic content and testing standards, several states teach environmental concepts as part of their overall curriculum.

Metrics: To measure progress for increased green chemistry capacity, several metrics are possible:

1. For Education and Training:
   - New curriculum and new academic disciplines offered
   - Number of graduates who have studied green chemistry and engineering concepts as part of their academic training
   - Number of K-12 school children whose curriculum included green chemistry and engineering concepts as part of their core subjects

2. For Research and Development:
   - New and increased investments in green materials and products companies
   - Other possible indicators now used in research and development that could be adapted for green chemistry and engineering elements
   - Number of new patents issued (Figure 7, page 23)

3. For Technology Transfer and Commercialization:
   - Establishment of Technology Transfer Centers for research and development
   - Number of new companies created
   - New and expanded export markets for California companies
   - Relative economic growth created by technological innovation (see Milken Institute metric discussion on page 22)

Compliance: This strategy would not be regulatory in nature. Increased investment—in the public and private sectors—is crucial to increase California's green chemistry workforce and technological capacity. A fee on products with toxic ingredients and/or those that impose a long-term waste management cost to California taxpayers might be considered to fund fundamental research grants, graduate fellowships and technology transfer incubator centers. For the public sector, appropriate programs, goals and incentives could be considered as part of the state's annual budget process.

Policy Recommendation Three

Create an Online Product Ingredient Network

Vision: California businesses, retailers and consumers can access non-confidential information about chemicals (including nanomaterials) found in the products and goods they purchase in California. Manufacturers, importers and retailers of consumer products will disclose chemical ingredients for products sold in California. California can ensure that laws restricting or banning toxic ingredients in consumer products are consistently enforced and can ensure a level-playing field for businesses. California consumers can make better decisions for the health and safety of their families when selecting product.

Figure 8. Create an Online Product Ingredient Network

Description: Product manufacturers and suppliers should disclose all chemical ingredients, including nanomaterials, in products sold in California. A web-based data network should be established which allows users to access a list of the chemical ingredients for an individual product. Confidential business information should be protected but accessible by a designated state agency to determine whether protected information includes a hazardous chemical. All other chemical ingredient information would be available to any interested person via the web-based network.

How: California should require disclosure of chemical ingredients of products sold in California, while protecting confidential business information. A phase-in schedule may be considered so product ingredient disclosure is orderly, efficient and effective.

To optimize and standardize implementation of the online product ingredient network, manufacturers or suppliers would disclose product ingredients using an international standard identification system for each chemical ingredient and each product. For example, each chemical could be identified by its Chemical Abstract Service (CAS) number, International Union of Pure and Applied Chemistry (IUPAC) number, or International Nomenclature of Cosmetic Ingredients (INCI) number. Each product could be identified by its Uniform Product Code or barcode "tag." Using a state-of-the-art search algorithm via a portal to the online network, the product and chemical ingredient information (stored on the manufacturer or supplier's information systems) can be queried and viewed. This online network portal would be modeled on advanced data systems now in widespread use—including common search tools—and would be developed in collaboration with the information technology sector. The web-based search portal algorithm would be updated periodically to ensure consistent and easy access to this information.

For those products or ingredients for which the owner claims confidential business information, the information would be accessible to a designated state agency that would establish security criteria to protect the confidential information.

Why: Disclosing chemical ingredients in products provides essential information throughout the supply chain. With this information, raw material and feedstock suppliers, chemical intermediaries, suppliers, wholesalers, producers, manufacturers, distributors, retailers, consumers and end-users can make better informed choices. Each step in the supply chain must know which chemicals are found in which materials and products to make informed decisions about whether to use or substitute a particular chemical, intermediary, or feedstock.

Using the online product ingredient network, businesses can avoid selecting toxic ingredients which could otherwise injure their reputation, create toxic tort liability, endanger worker safety, or result in costly waste management or clean-up liabilities.

Toxics in Products Laws: Ad Hoc Enforcement Provisions Hinder the Goal of Improved Public Safety

In the last five years, California has enacted statutes to ban lead in jewelry, mercury in switches, toxics in packaging, lead in faucets, phthalates in toys, flame retardants in furniture, heavy metals in electronics and mercury in light bulbs, as well as to require ingredient disclosure in cosmetics. Some of the laws establish unique enforcement regimes under multiple state agencies – and some have no enforcement authority. The result is a haphazard set of laws that result in an uneven playing field and no assurance of achieving the intended health and safety protections for the public.

This information would allow manufacturers, retailers and ultimately consumers to make informed choices about the products they buy and use. It will also create a level playing field for California products and foreign competitors. Disclosure of the presence or absence of specific chemicals (including nanomaterials) in specific products would enable government to act quickly in response to emerging data about environmental and public health issues associated with those chemicals. The security infrastructure, or "virtual vault," would protect competitiveness and confidential information.

Funding: The development and operation of the web-based portal could be supported by its direct users—product manufacturers, suppliers and retailers who sell products and goods in California. The administrator of this data network could charge appropriate costs to those users. Those assessments could be a fixed amount or based on a sliding scale, as the administrator and users agree, and as necessary, to support the long-term operation and security of the network. Any state costs to determine and audit claims of confidential business information could be assessed to the claimant manufacturer and/or supplier.

Other States and Governments: No other state or national government has developed a product ingredient disclosure system for consumer products.

Metrics: Progress toward more complete, accessible information about which chemicals are found in products could be measured by the following metrics:

- Number of sectors (SIC code groups) for which chemical ingredient and nanomaterial information has been made accessible
- Number of products sold in California for which chemical ingredient and nanomaterial information has been made accessible

Compliance: Product manufacturers and or retailers who sell products in California would be required to disclose chemical ingredients for products they sell in California.

Policy Recommendation Four

Create an Online Toxics Clearinghouse

Vision: Building on efforts by other governments and authoritative bodies worldwide, California fills chemical information gaps by ensuring that hazard trait and toxicity data is developed and made publicly accessible via an online toxics clearinghouse. This clearinghouse (portal) will improve the ability of businesses, government and consumers to make better decisions that lead to safer choices.

Figure 9. Create an Online Toxics Clearinghouse

Description: California should establish a web-based clearinghouse portal to information containing specific chemical hazard trait and toxicological end-point data for all chemicals, including chemical compounds and nanomaterials. This chemical data should include information from a variety of authoritative sources, including California's environmental regulatory programs, U.S. EPA, other nations and other states.

How: Similar to the product ingredient disclosure system recommended in Policy Recommendation Three, an online toxics clearinghouse portal should be established (using modern information technology algorithms). To do this, California would follow a multi-step process that: (1) determines the hazard traits and toxicological end-points to be used in the online clearinghouse; (2) identifies existing sources for these data; and (3) prioritizes those chemicals of concern that will be the starting point for "populating" the online clearinghouse.

An online toxics clearinghouse should be established. As a preliminary step, the types of data (hazard traits or toxicological end-points) that will be part of the clearinghouse should be identified. A state agency, using a transparent and public process, should solicit input and select the chemical hazard trait and toxicological end-point data elements that will be used in the clearinghouse portal.

After the specific data elements are determined, a web-based search engine should be created and used to electronically access that data for all chemicals, including chemical compounds and nanomaterials.

To avoid duplication of effort or expense to California, this clearinghouse should be populated with data from existing sources first. California should establish agreements with other governments (such as the European Union, Japan and Canada) and authoritative bodies (such as the International Agency for Research on Cancer) to access their data on chemicals. Data sharing agreements and memoranda of understanding should be reached with other states such as Maine, Massachusetts, Washington and Oregon and the federal government that are also making new toxicity data available. As appropriate, chemical hazard and toxicity data from chemical producers and industry could be accessed and included in the online clearinghouse.

Similarly, this clearinghouse should not duplicate California's existing environmental regulatory programs that generate chemical toxicity information. These programs include the Water Quality Standards Program, the Pesticide Registration Program, the Toxic Air Contaminant and Air Toxics Hot Spots Program, public health goals for drinking water contaminants and Proposition 65. These data could be considered as part of the initial "input" for the clearinghouse. A graphic showing many of the potential types of data (range of hazard traits and sources of toxicity data) from existing regulatory programs and other authorities is included in Appendix E.

Next, for those chemicals for which data is currently incomplete or unavailable, a prioritization scheme must be established so information about those chemicals of highest concern to California can be developed and added to the online clearinghouse. This prioritization process could be conducted in several ways. For instance, California could convene a panel of scientific experts who would advise the state regarding which chemicals should be included in the first priority rank. The Cal/EPA Secretary or a designated state agency would consider the panel's advice and also invite public comment. The Secretary, a designated state agency, or a plural decision-making body such as the Environmental Policy Council (comprised of the heads of all the state agencies with jurisdiction over public health, safety and the environment) would consider all input and other appropriate matters when determining the prioritization ranking.

Why: For many chemicals, information about the toxicity and hazards traits is inadequate or unknown. Businesses, consumer and regulators often lack information on chemicals and their properties. Businesses find it difficult to identify hazardous chemicals in their supply chains. Consumers do not know which chemicals are in the products they buy and whether those may be toxic. Government agencies lack information to support regulatory actions. These critical information gaps prevent the free market from working properly to stimulate innovation of safer substitutes.

Establishing the online toxics clearinghouse will increase information so chemical toxicity research focuses on priority chemicals, markets accelerate the transition to less toxic alternatives and everyone throughout the supply chain can make better decisions and safer choices.

Funding: Development and operation of the online toxics clearinghouse should be built on existing authoritative bodies, such as the European Union, Japan, Canada, and other states. The administrator of the clearinghouse could charge appropriate costs to the direct users or apply other business models appropriate for online information. Any state costs associated with the development of the hazard traits and end-points data elements and prioritization and ranking of chemicals could be assessed to chemical producers and suppliers.

Other States and Governments: Recent legislation in Washington and Maine requires the respective environmental agencies to identify a specified number of chemicals of high concern, based on specified hazard endpoints. Massachusetts has long maintained a list of higher-hazard chemicals for priority-setting under its Toxic Use Reduction Act Program. The federal U.S. EPA has several voluntary programs, including the High Production Volume Challenge Program, to compile chemical toxicity and hazard information for selected chemicals.

CEPA, the Canadian Environmental Protection Act, enacted in 1999, used available existing information to categorize chemicals in its national inventory, identifying more than 4,000 chemicals that possessed hazard or exposure characteristics of potential concern.
Canada has conducted further assessments of these chemicals, focused on about 200 high-priority chemicals. Canada is currently collecting data from manufacturers and importers for the high priority chemicals.

Canada has conducted a robust priority-setting process as part of its Chemical Management Plan using existing toxicity data and mathematical modeling. The Canadian lists may serve as a starting point for California's prioritization ranking efforts.

The European Union (EU) has enacted the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) Act, which requires the chemical industry to assess and manage the risks posed by chemicals and provide appropriate safety information to their users.

EU REACH is the European Union Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), a law that went into effect in June 2007. It requires toxicity data to be registered with a new **European Chemicals Agency** in Helsinki for substances sold in the EU in quantities greater than 1 metric ton per year per company and evaluated for further testing. Ultimately, the EU may develop an authorization system to control substances of very high concern and progressively replace them with suitable alternatives where economically and technically viable, unless there is an overall benefit for society of using the substance.

Metrics: Toxicity end-point data is sparse or currently non-existent for a large number of chemicals (with the exception of pesticides and pharmaceuticals). A significant opportunity exists to fill this large data gap, improve the baseline of information and improve our ability to invent and move to safer chemistries. Specific metrics that could be used to assess progress in filling chemical information gaps and the online clearinghouse include:

- Percentage of chemicals in the clearinghouse with no hazard trait data
- Percentage of chemicals in clearinghouse with data on hazard traits of highest concern
- Percentage of chemicals in clearinghouse with complete hazardous trait data
- Number of emerging chemicals identified as being of high hazard concern
- Number of safer alternatives identified using the data housed in the clearinghouse

Compliance: Initially, the availability of the specified data should be audited to determine if data required in the first priority rank has been generated and made accessible. A designated state agency should monitor the clearinghouse. In the future, penalties for failure to make data accessible could be considered.

Policy Recommendation Five

Accelerate the Quest for Safer Products

Vision: California establishes a scientifically-based decision-making framework to evaluate chemicals of concern in products sold in the state and to prompt manufacturers of those products to use less toxic alternatives. By applying lifecycle thinking at the design stage, manufacturers find and use "greener" alternatives through design changes, product reformulation, product and input substitutions and other options. While toxicity information continues to be developed, consumers are protected more promptly as safer products replace those containing chemicals of concern.

Figure 10. Accelerate the Quest for Safer Products

Description: Chemicals of concern in products should be identified, promptly evaluated and then replaced, redesigned, restricted, or banned using lifecycle thinking principles. While toxicological and hazard trait data (or its absence) informs this process, alternatives analysis does not depend solely on complete toxicological data—rather it combines and synthesizes thinking on cleaner production, risk assessment and risk management, green chemistry, sustainable materials and product design. An alternatives analysis, which is a comparative tool and considers many factors, can begin when a specific concern arises.

Manufacturers, importers and retailers of products that are sold in California and that contain a chemical of concern would conduct this analysis to determine whether a safer alternative exists or is feasible. From that analysis, a range of regulatory actions are possible: additional research and development, technology development, phase-outs and bans, restrictions on use, engineering controls, best management practices, monitoring and extended producer responsibility.

How: Develop a science-based alternatives analysis decision-making framework, based on lifecycle thinking. The framework should include criteria to determine when a chemical of concern should be evaluated and whether an alternatives analysis will be required. These criteria should be developed through a transparent, public regulatory process and revised over time as more knowledge and better tools become available. The state should expand the role and membership of the Environmental Policy Council, to include heads of all state agencies with public health, safety and environmental jurisdiction, to review and identify the alternatives analysis framework to ensure multimedia considerations are adequately incorporated and balanced.

Figure 11. Conceptual Model for Alternatives Analysis. *e selection of an alternatives analysis depends upon the use and function of the product or chemical and the methods used to consider factors such as health and environmental impacts, social considerations, economic feasibility and technical features. Source: Rossi, Tickner and Geiser, Alternatives Assessment Framework of the Lowell Center for Sustainable Production, July 2006.*

In alternatives analysis, different outcomes are possible for the same chemical in different products. A product manufacturer, for example, may determine that a substitute for a chemical is readily available, cost-competitive and less hazardous. The same chemical used in a different product may require further research to identify a feasible alternative or to determine if restrictions, including extended producer responsibility, may be required.

The state should establish a California Green Products Registry (CGPR), a non-governmental organization modeled after various consensus standards organizations, such as the American National Standards Institute (ANSI), International Standards Organization (ISO), Society of Automobile Engineers (SAE) and the U.S. Green Buildings Council (USGBC). This non-governmental consensus standards organization should be responsible for developing and improving the methodologies and protocols for lifecycle thinking, supporting industry and retailers in applying those methodologies, and providing multi-sector information about trends across broad economic sectors to industry and government.

The most important aspect of **alternatives analysis** is that it reorients environmental protection discussions from problems to solutions. For example, chlorinated solvents are used for degreasing and cleaning. Once we understand this function, it is possible to think of a range of alternatives, such as ultrasonic cleaning or **less toxic** aqueous cleaners or even redesigning a metal part so that the need for cleaning is eliminated altogether.

Why: In most cases, California lacks a comprehensive framework for expediting the replacement or adoption of safer alternatives when a toxic substance is found in products. As such, California has been addressing toxic chemicals in products with ad hoc statutory bans of specific chemicals. While appropriate in some instances, bans often overlook the health and environmental implications of the chemicals that replace the banned one. These replacement chemicals may have significant unforeseen effects and perhaps increased risks, over the banned chemical. This ad hoc ban approach, without a means to make comparisons, stymies innovation and slows substitution of safer chemicals.

Given the huge array of products and chemical ingredients in those products, a systematic and consistent approach is critical so California can ensure that items purchased and used in the state do not harm the health and safety of our people or our environment. The current practice concentrates government resources on determining the degree of risk or hazard of a single chemical. We do not have a means to consider and compare alternatives that can enhance health and safety, reduce risk and improve performance using the best available information

Traditional risk assessment has been the predominant tool for decision-makers over the last 20 years. While risk assessment and toxicity testing must continue, society demands additional tools to reduce uncertainty and improve product safety while those efforts continue. California needs new tools for generating toxicological information, for assessing chemicals in products and for comparing alternatives.

Lifecycle assessment (also known as lifecycle analysis) is another useful tool but can also be time-intensive. A lifecycle assessment requires comprehensive documentation and evaluation of specified factors such as resource use, health effects and ecological impact. The results of lifecycle assessment can be problematic if the prescriptive methodology is not followed.

Because our present tools are labor and resource intensive and require substantial data, appropriate action on a chemical of concern may be delayed. Moreover, the potential alternatives are not identified or explored with the current tools. Using lifecycle thinking and comparing alternatives is an opportunity to act in a timely and effective manner to reduce the risk or hazard. Alternatives analysis calls attention to current and "on-the-horizon" alternatives. Resources that might otherwise be directed solely to the expensive and time-consuming process of characterizing problems can then focus on solutions.

An alternatives analysis model offers a systematic means of comparing options, weighing different hazard traits and environmental endpoints, and considering production, performance and cost factors as well as other appropriate attributes. Both government and industry will be able to make more informed decisions about substitution, reformulation, restrictions and bans. With good design, alternatives analysis can be conducted with present scientific information, at less cost and in less time. Alternatives analysis with lifecycle thinking shifts society's resources toward safer solutions that also enhance innovation and economic growth.

Funding: Funding mechanisms must be explored. For instance, the California Green Products Registry, a non-governmental consensus standards organization, could be established and assist both government and industry in developing, adapting and using alternatives analysis protocols and lifecycle tools (models for similar organizations are discussed on page 30 of this report). This organization could assess its membership, obtain tax-exempt contributions, receive grants and use other funding mechanisms. State governmental costs could be funded by assessments on the respective industry sectors and product manufacturers.

Other States and Governments: Several other U.S. states—Maine, Michigan, Oregon and Washington are implementing new statutory programs to regulate specific chemicals in specific products. Many local jurisdictions (mostly municipalities) have enacted restrictions, prohibitions and bans on certain chemical ingredients in specified products, such as polystyrene food containers and plastic grocery bags.

The European Union and Canada are implementing new programs that regulate chemicals, under EU REACH and Canadian Environmental Protection Act (CEPA) laws.

Metrics: Possible metrics for alternatives analysis to find and select safer, greener products include:

- Environmental footprint shrinking—measuring the relative change in the footprint over time
- The number of chemicals for which evaluations are required following a "trigger" event
- The number of products that are redesigned, reformulated, or otherwise assessed using alternative analysis methodologies, including lifecycle approaches
- The estimated volume of hazardous chemical(s) minimized or avoided through alternatives analysis

Compliance: In collaboration with stakeholders and the CGPR, the state would determine if alternative analysis methodologies are effective and efficient in reducing risk and hazard from chemicals of concern in products. The state could require specified response actions, where warranted and enforce those actions accordingly.

The 12 Principles of Green Chemistry are:

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.

Source: Anastas and Warner, Green Chemistry: Theory and Practice (1998)

Policy Recommendation Six

Move Toward a Cradle-to-Cradle Economy

Vision: California's environmental footprint is reduced through continuous innovation and design strategies that reduce production costs, improve quality, optimize resource use and generate less waste and pollution. Industries manufacture, sell and distribute "greener" products to California retailers and consumers (see Figure 12, right). Retailers—through their sourcing decisions—inspire designers and upstream industry to consider the lifecycle of the products they produce. The design of products shifts from the narrow focus on technical fabrication and function to include resource inputs, toxicity of substances used and end-of-life considerations. At the design stage, manufacturers consider which types of resources and industrial processes would be used. These decisions ultimately determine the safety and environmental characteristics of the finished product.

> **"Our Governor has a true vision and belief that the green economy can thrive here in our state and he's not waiting for the federal government to prove him right, he's taking the lead and setting the example. As with our green buildings and green fleet, the Green Chemistry Initiative is another set of policies to help lead the way for a green California."**
>
> *Rosario Marin, Secretary of the California State and Consumer Services Agency*

California is at the forefront of new green chemistry and green engineering technologies, processes and materials that are "benign by design." Leveraging this evolution of new "greener" product design, California enjoys a competitive advantage in the rapidly growing global marketplace. Californians supply the green products and technologies emerging from investments and innovation in nanotechnology, "clean tech," biotech, climate change and energy use reduction strategies and other new scientific discoveries. California expands its high-skill, high-wage jobs, greener and safer products and more efficient resource use through this vast global materials and consumer products market.

Figure 12. Move Toward a Cradle-to-Cradle Economy

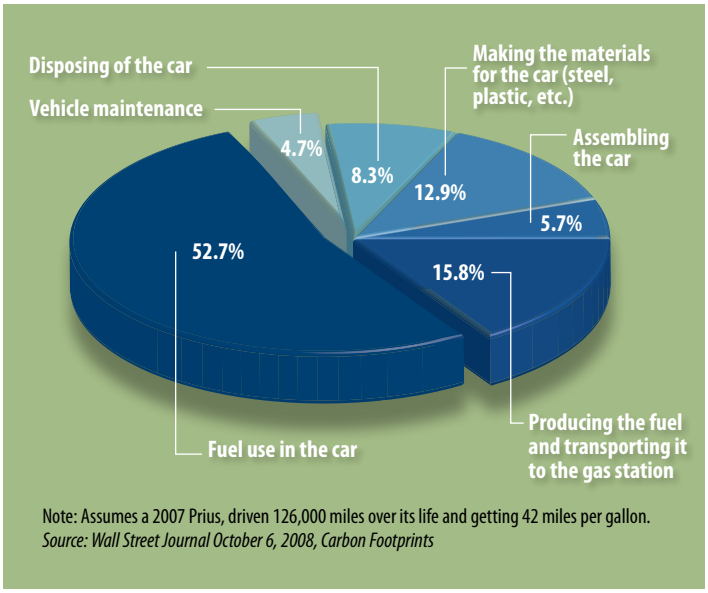
Description: Product manufacturers that sell products in California should provide to retailers and consumers a sustainability metric—an environmental footprint calculator, index or "green scorecard" (not a label)—for their products or categories of products. The metric should be developed based on existing lifecycle approaches and models. Retailers should voluntarily assess their portfolio of products, set their own continuous environmental improvement targets and make the results of those efforts available to the public.

Lifecycle thinking allows consideration and balancing of different factors, including product performance, reliability, safety and toxicity, resource consumption, waste and disposal, climate change, energy efficiency, water conservation and costs. By placing added emphasis on all of the factors and attributes of a particular product, green design or lifecycle thinking can optimize materials and energy efficiency as well as change the systems or networks for production, distribution and consumption of such products.

How: A new systems-oriented green design and engineering philosophy will promote innovation. In principle, aggregate indicators such as materials or energy intensity, input-output exchanges, environmental

performance, carbon footprint and other new techniques would be developed collaboratively. Retailers would be encouraged to apply these to their product portfolios to foster continuous improvement (see Figure 14, below). Retailers would work with their supply chains, who would change product design, substitute less hazardous ingredients, offer extended producer responsibility or take-back programs and other potential ways to help retailers meet their self-determined targets.

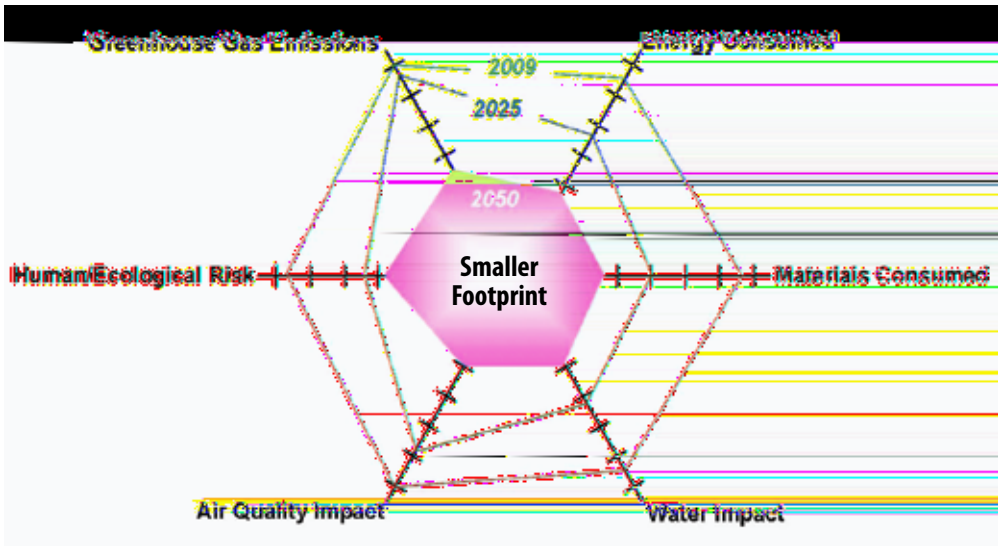
Figure 13. Carbon Footprint of Automobile



The sustainability or "environmental footprint calculator" would generate a score that would indicate a product's relative environmental impact or "greenness level." Numerous calculators are now widely available and can be tailored to meet the specific needs for calculating the footprint of a manufactured product.

There are many examples of businesses and organizations that use such metrics. The USGBC, Patagonia, Levi-Strauss, Wal-Mart and Timberland have created and currently use environmental scorecards, rating systems or environmental footprint calculators for buildings, clothing, household cleaners and shoes, respectively. Many of these have the potential to be used as prototypes for the development of a California Green Scorecard—an approach that is more informative than a green label.

Figure 14. Reducing a Product's Environmental Footprint. is spider diagram is one way to show how a particular product's environmental e ects or "footprint" are reduced over time through incremental improvements in sustainable design. is diagram shows the dimensions of the footprint in years 2009, 2025 and 2050.



Conceptually, with the information provided by product manufacturers, California retailers would assess their own portfolio of products and then set a "baseline." Retailers would then set their own "targets" for continuous improvement from their baseline toward safer, more sustainable products or product categories (see Figure 15, page 36). Retailers would set their own targets based on the attributes (properties of a product or service) that they select as the best means of increasing sustainability according to their own particular goals.

Figure 15. Sustainable Green Metric Growth

The California Green Products Registry, a non-governmental organization, should be established and could include a membership of lifecycle thinkers, environmental advocates, product developers and retailers who could develop consensus-based green metrics, protocols and tools. These tools will assist product manufacturers and retailers in achieving their target goals. These tools might include environmental footprint calculators, scorecards and sustainability indices. Further discussion and examples are included in Appendix F.

Voluntary goals could be established for green products targets. These goals will allow the metrics, tools and system to mature, which will benefit all retailers, but will be essential for small retailers. The state may also take into consideration that it may be more advantageous to start with products with the largest environmental footprints and those already subject to the widest range of environmental goals, restrictions and targets for specified environmental endpoints (e.g., automobiles or large appliances) or those where industry leaders have already established such tools (e.g., carpets, household cleaners and clothing). The state would then proceed to products with smaller environmental footprints or for products where development of such tools will take longer.

Consumer education and outreach would help create public demand and help the retailer achieve their targets. For further detail on how consumer education and outreach might be accomplished, see the report of the Key Element Team outlining some options in Appendix D-1.

Why: Implementation of this policy recommendation would start infusing the California marketplace with lifecycle thinking and accelerate the innovation and selection of sustainable, less toxic choices for consumers, retailers and the entire supply chain. Through the unique ability that retailers have to translate consumer demand into sourcing decisions, they would foster new designs for chemicals, processes and products based on relative hazards and environmental impacts throughout the lifecycle.

Since the majority of products consumed in California are manufactured out-of-state, our traditional regulatory approach does not foster innovation in products or the widespread development and adoption of green chemistry principles for products consumed in California. Moving to a focus on the environmental footprint of products could establish global consensus-based criteria for producing sustainable products and begin to level the playing field for California manufacturers. A common set of standards would provide a competitive advantage to those products designed and manufactured according to the most environmentally- and health-protective standards. This would be a great advantage to California businesses, while benefiting public health and the environment.

Retailers, through their sourcing decisions, will inspire designers and manufacturers to design products with reduced lifecycle impacts. Better sourcing decisions will protect people from harmful chemicals; avoid cradle-to-grave expensive cleanup costs and liabilities; allow markets to choose how to achieve the greatest environmental cost reductions; level the playing field for those manufacturers that are producing greener products; reduce risks of false "green" product claims or "greenwashing"; and contribute to solutions for energy, climate change and water pollution.

Greenwashing is a term that describes **misleading claims** about the **environmental safety** and effects of a product or service.

Multi-stakeholder, consensus-based standards take time to develop. However, once clear criteria and performance standards for "greenness" are established and garner widespread acceptance, their adoption by industry leaders leads to triple bottom line gains throughout the supply chain (see figure 3, page 17). For instance, the carpet industry collaborated with the National Science Foundation and the American National Standards Institute (ANSI) to develop lifecycle criteria and metrics for carpets. In so doing, the carpet industry provided valuable information to supply chain stakeholders. From this information, stakeholders identified sustainable attributes which enabled competition between manufacturers and their suppliers to seek out or develop environmentally preferable processes, practices, power sources and materials. Stimulating competition among market participants to reduce their product's environmental impacts and costs is the key goal of this policy recommendation. Without accounting for these costs or having a consistent way to measure them across product categories, businesses have no incentive to reduce them outside of government mandates, toxic tort and waste management liabilities. Establishing consensus-based metrics and allowing apples-to-apples comparison among product types, this policy recommendation has the potential to apply "Moore's Law" to products. With the profit motive and market competitiveness as its ally, California's environment and our public health have the potential to see great gains at increasingly lower cost.

Moore's Law refers to the prediction made in 1965 by Gordon Moore of Intel, that innovation would drive computer memory to double in capacity and speed every 18 months. Today, this principle also translates into an exponential reduction in cost.

Can this law apply to environmental protection as it did for computer memory?

As retailers and consumers select environmentally preferable products, manufacturers and those products gain a competitive advantage. As they gain marketshare and reduce cost, California also gains significant increases in environmental protection.

Funding: A California Green Products Registry should be established to assist manufacturers and retailers in developing and using sustainable or "environmental footprint" protocols, tools and metrics. The Registry could fund its on-going operations from assessments to its membership, tax-exempt contributions and grants. Retailers could work with their suppliers and supply networks to inventory products, assess lifecycle factors, establish baselines, set targets and measure performance.

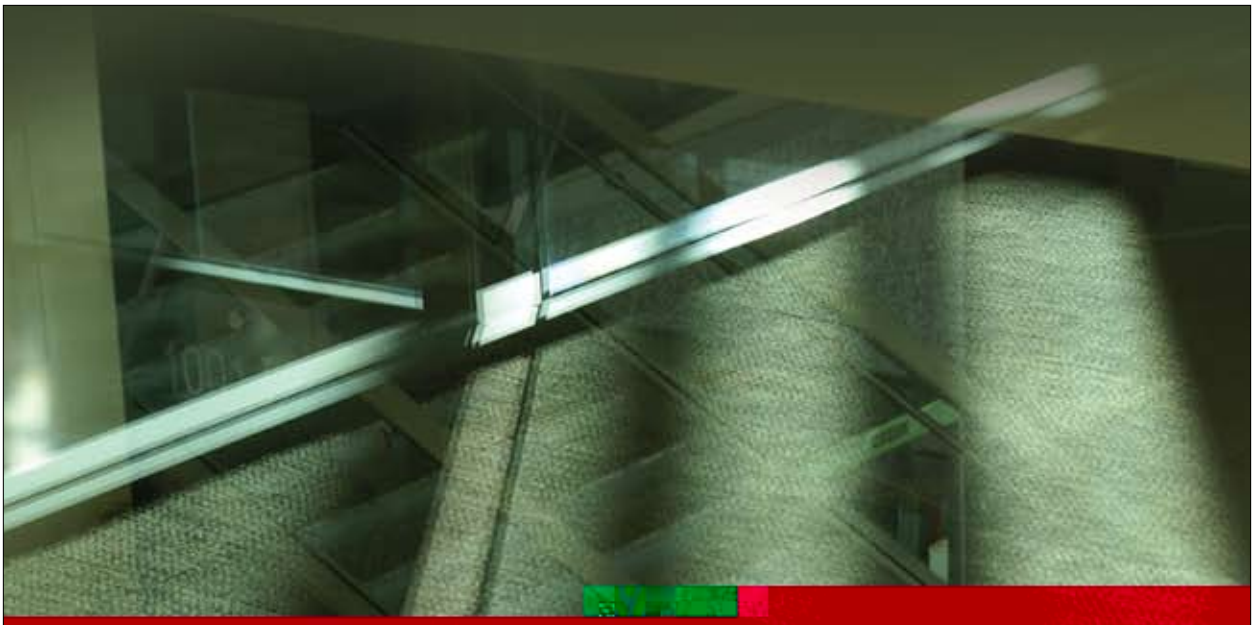
Other States and Governments: No state or nation has instituted a comprehensive effort focused on consumer products and the chemicals used in those products. The International Organization for Economic Cooperation and Development (OECD) has begun efforts to develop lifecycle tools and apply those to environmental issues, eventually including consumer products. The Netherlands is embarking on the design of a cradle-to-cradle economy. For the most part, European and other international programs are voluntary. Many of these programs involve various labeling or certification schemes.

Other U.S. states—Maine and Washington—are implementing new statutory programs to regulate specific chemicals in specific products. Many states have implemented commodity-specific programs that focus on reducing or recycling certain products that contain specified hazardous chemicals such as used oil, tires and batteries. Some of these state-based programs are being implemented at the retail level.

A number of local jurisdictions have banned polystyrene take-out food packaging, including the cities of Alameda, Calabasas, Carmel, Emeryville, Long Beach, Los Angeles and Orange County. Some municipalities have also banned plastic grocery bags, typically requiring the use of compostable plastic. The cities of San Francisco, Los Angeles, San Jose and Palo Alto require that retailers meet plastics reduction and recycling goals.

Metrics: The California Green Products Registry would devise new metrics, tools and protocols based on lifecycle methodologies. Product manufacturers would apply these for their products and product categories. Retailers would use them for their product portfolios baseline and to set their targets for improvement. These quantifiable data may vary across different types or categories of products given the wide array of manufactured goods and chemical-formulated products. Once an environmental footprint calculator is established, the Registry would continue to refine and enhance ts5inwlede ovems vemr tim,

IV. Next Steps



IV. Next Steps

Californians have an abiding interest in protecting their children, their health, their communities and the natural splendor of their state. Making consumer products and goods safer is a critical first step. Green chemistry and lifecycle design techniques will accelerate our transition toward a more sustainable economy, increase opportunity and enhance environmental quality. California will be at the forefront in developing

V. Acknowledgements

V. Acknowledgements

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State Air Resources Board
State Water Resources Control Board
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VI. Glossary of Terms and Acronyms A - C

VI. Glossary of Terms and Acronyms C - H

Cradle-to-Cradle	Phrase coined by Walter R. Stahel in the 1970s and popularized by William McDonough and Michael Braungart in their 2002 book, *Cradle-to-Cradle: Remaking the Way We Make Things*. This framework seeks to create production techniques that are not just efficient but are essentially waste free. It is described as the transformation of human industry through ecologically intelligent design.
Cradle-to-Grave	Phrase which refers to the life of a product or good from its manufacture (cradle) to disposal (grave). In U.S. law, the hazardous waste program, under the *Resource Conservation and Recovery Act,* establishes a system for controlling hazardous waste from the time it is generated to its ultimate disposal – in effect, from "cradle to grave".
CSU	California State University (CSU) system, which includes 23 campuses throughout the state and is the largest university system in the U.S.
DTSC	Department of Toxic Substances Control (DTSC). See Government Code section 12812.
EEI	Education and the Environment Initiative (EEI), a program which develops curriculum and supplemental materials, based on environmental principles and concepts, to teach math, science and language in California's primary and secondary schools. See Education Code section 33541 et. seq.
End-of-Life	Refers to the time when a product's value to the user, generally the first user, has been expended and the product is available for reuse, recycling, or disposal.
End-of-Pipe	Refers to the terminus of waste treatment and control technologies; the point of discharge, release, or disposal. Under U.S. law, the point at which regulatory permit limits apply.
Endpoints	Refers to toxicological testing results which may be used to classify a chemical or compound. Currently, most toxicology studies rely on observation outcomes of exposure, such as developmental anomalies, breeding behaviors, impaired reproduction, physical changes and alterations in the size and histopathology of organs, and, death.
Environmental Footprint	Refers to a quantifiable measure of the cumulative impacts of a process, activity, or population on the state's environment.
EU REACH	European Union *Registration, Evaluation, Authorization and Restriction of Chemical Substances* (EU REACH), a European Community law that took effect on June 1, 2007. Manufacturers and importers will be required to gather information on the properties of their chemical substances, which will allow their safe handling, and to register the information in a central database run by the European Chemicals Agency (ECHA) in Helsinki.
Extended Producer Responsibility	Extended Producer Responsibility (EPR), which is one of several possible regulatory outcomes after an alternatives analysis is conducted. EPR is also a key provision in the California Integrated Waste Management Board's directives.
GDP	Gross Domestic Product (GDP) is one of the measures of income and output for a given economy, usually a national government.
Green Chemistry	Refers to the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances and toxic chemicals.
Green Engineering	Refers to the design, commercialization and use of processes and technologies, which are feasible and economical while minimizing generation of pollution and risks to human health and the environment. [Shonnard, NAS]
Hazard Trait	Refers to characteristics of a chemical that can be used to assess potential adverse effects, including death, fire, explosion, irritation, burn, injury, illness, disease, cancer, birth defects, reproductive harm, plant and animal damages, etc.

VI. Glossary of Terms and Acronyms 1 - O

Hazardous Substance	Refers to a chemical which may cause injury or illness or harm the environment; synonymous with hazardous chemical, toxic chemical, toxic substance, and related terms for this report.
ISO	International Organization for Standardization (ISO), a network of the national standards institutes of 157 countries, one member per country, with a Central Secretariat in Geneva, Switzerland, that coordinates the system. ISO is a non-governmental organization that forms a bridge between the public and private sectors. Many of its member institutes are part of the governmental structure of their countries, or are mandated by their government. Other members have their roots uniquely in the private sector, having been set up by national partnerships of industry associations. See also ANSI above.
K-12	Refers to public school primary and secondary grade levels, kindergarten through twelfth grade.
LCA	Lifecycle analysis; see "lifecycle assessment".
LEED™	Leadership in Energy and Environmental Design (LEED), the U.S. Green Building Council's green building rating system.
Lifecycle	Refers to the major activities in the course of the product's life span from its design, raw materials, resource inputs, manufacture, use, operation, resource consumption, wastes generation, maintenance, and final disposal.
Lifecycle Assessment	A technique for assessing the environmental aspects and potential impacts associated with a product or process. Often used interchangeably with lifecycle analysis.
Lifecycle Thinking	Refers to the application of lifecycle principles to business practices. Lifecycle thinking involves examining the environmental sustainability over the product's entire life – from raw materials selection, manufacturing, transportation, use and end of life disposal or reuse and waste management. Tools, metrics and approaches using lifecycle thinking are often used to determine a product's "environmental footprint." Also called lifecycle approaches or lifecycle management.
Manufacturer	Refers to any person, firm, association, partnership, or corporation producing a substance, mixture of substances, a chemical, or a product or good which contains chemicals.
Metrics	Refers to methods for measuring or assessing performance.
Moore's Law	Refers to Gordon Moore's observation, in a 1965 journal article, that the number of transistors on an integrated circuit was increasing exponentially every 18 months. Carver Mead, Caltech, coined the phrase "Moore's Law," which now refers to exponential increases in capacity (function, speed, density, storage, etc.)—along with similar decreases in cost and size—for many technology sectors and industries.
Multimedia	Refers to the whole environment, specifically simultaneous impacts to air, water, and soil and to the plants, animals, habitats, people, and communities that depend on clean air, water, and land.
Nanotechnology	Refers to the design and engineering of chemicals, materials, and even machines that are extremely small (one nanometer in size, or about 1 billionth of a meter). Also nanoscale.
OECD	Organization for Economic Co-operation and Development (OECD), an international organization based in Paris. OECD provides governments with the analytical basis to develop environmental policies that are effective and economically efficient, including through performance reviews, data collection, policy analysis, and projections.

VI. Glossary of Terms and Acronyms Q - V

QSAR	Quantitative Structure Activity Relationship (QSAR), a model for assessing chemical toxicity and health risk. QSAR correlates biological activity (such as carcinogenicity) with structural or physical characteristics of chemicals and compounds.
REACH	See EU REACH.
Read-Across (Method)	Refers to a non-testing alternative approach for chemical risk assessment; closely related to QSAR.
Retailer	Refers to any person or business engaged in the selling to the consumer, not for the purpose of resale, of any product, good, or item.
SAE	Society of Automobile Engineers (SAE), an international organization comprised of engineers, business executives, educators and students who share information and exchange ideas for advancing the engineering of mobility systems. SAE Technical Reports and Standards are developed by the organization's more than 700 Technical Committees. Participation is open to all interested parties.
Source Reduction	Also known as "waste prevention" or "pollution prevention," is the practice of designing, manufacturing, purchasing, or using materials (such as products and packaging) in ways that reduce the amount or toxicity of trash created.
Sustainable Design	Refers to the design of products to comply with economic, social and ecological needs while reducing negative impacts on human health and the environment.
Through-Put (Method)	Refers to a rapid screening method to assess chemical toxicity. Through-put methods are an evolving health risk assessment tool.
Toxicity	Refers to the degree to which a substance affects an exposed organism (such as a human, animal, or plant) as well as cells and organs (such as the brain or liver). Toxicity assessment is one of four components of health risk assessments: (1) hazard identification, (2) toxicity or dose-response assessment, (3) exposure assessment, and (4) risk characterization.
Toxic Endpoints	See hazard trait, end-point.
Triple Bottom Line	Refers to a company's financial, environmental, and social performance. Also refers to a company's profits, derived from sales as well as cost savings from reductions in raw material inputs, resource consumption, waste management and disposal, liability and insurance, torts, etc.
UC	University of California (UC), which includes ten campuses, national laboratories, medical centers, and system-wide centers.
UPC	Universal Product Code (UPC), a specific type of bar code widely used in North America to track goods and products. Also stock keeping unit (SKU), a unique identifier for each distinct product.
Virtual Vault	Refers to an electronically secure system; information which only accessible via the Internet to an authorized user.

VII. Bibliography

Anastas, Paul T. and John C. Warner. *Green Chemistry: Theory and Practice.* Oxford University Press, 1998.

Ashford, Nicholas A. *An Innovation-Based Strategy for a Sustainable Environment. Innovation-Oriented Environmental Regulation: Theoretical Approach and Empirical Analysis. Proceedings of the International Conference of the European Commission Joint Research Centre,* May 27-29, 1999; pages 67-107.

Ashford, Nicholas A., Lars Koch. *Rethinking the role of information in chemicals policy: Implications for TSCA and REACH. Journal of Cleaner Production* (2006) 14: 31-36.

Ashford, Nicholas and Charles Caldart. *Technology, Law, and the Working Environment.* Van Nostrand Reinhold, 1991.

Bell, Ruth G. and James Wilson. *How Much is Too Much? Thoughts About the Use of Risk Assessment for Countries In Transition and the Developing World. Resources* (2000) Summer:10-13.

Braungart, Michael and William McDonough. *Cradle-to-Cradle: Remaking the Way We Make Things.* North Point Press, 2002.

Burtis, Patrick, Bob Epstein and Nicholas Parker. *Creating Cleantech Clusters: 2006 Update. E2, Environmental Entrepreneurs and Cleantech Venture Network, LLC.* May 2006.

California, Department of General Services. *Best Practices Manual.* Available at http://www.green.ca.gov/EPP/Introduction/default.htm.

California Environmental Protection Agency, California Resources Agency. *Environmental Protection Indicators for California.* April 2002.

California Environmental Protection Agency. *Toward the 21st Century: Planning for the Protection of California's Environment.* California Comparative Risk Project, May 1994.

California Integrated Waste Management Board. *Improving Used Oil Recycling in California.* May 2008.

California Legislative Analyst's Office. [Internet] *Cal/EPA: How well is it meeting its goals? 1998-1999 Budget Analysis.* Available at http://www.lao.ca.gov/laoapp/PubDetails.aspx?id=67.

California Legislative Analyst's Office. *Cal Facts: California's Economy and Budget in Perspective.* December 2006.

California Little Hoover Commission. *Organizing State Government to Meet California's Environmental Protection Priorities.* June 1991.

California Risk Assessment Advisory Committee. *Review of Cal/EPA Risk Assessment Practices, Policies, and Guidelines.* October 1996.

California Senate Office of Research. *Environmental Protections and Growth.* March 1996.

California Senate Office of Research. *California's Experience with Proposition 65: Implementing the Safe Drinking Water and Toxic Enforcement Act.* March 1990.

California Unified Environmental Statute Commission. *Unifying Environmental Protection in California.* January 1997.

Centers for Occupational and Environmental Health, University of California. *Green Chemistry: Cornerstone to a Sustainable California.* University of California, 2008.

Consumer Product Safety Commission. *Regulated Products.* Available at www.cpsc.gov/businessinfo/reg.html

Consumer Product Safety Commission. *Child Safety Protection Act Fact Sheet.* Available at www.cpsc.gov/cpscpub/pubs/282.html.

Environmental Products Declarations: The Green Yardstick. [Internet] Available at http://www.environdec.com/pageId.asp?id=301&menu=2,2,26.

Fava, J., R. Denison, B. Jones, M.A. Curran, B. Vigon, S. Selke, J. Barnum, eds. *A Technical Framework for Life Cycle Assessment.* Society of Environmental Toxicology and Chemistry, 1991.

Fava, J., F. Consoli, R. Denison, K. Dickson, T. Mohin, B. Vignon, eds. *A Conceptual Framework for Life-Cycle Impact Assessment.* Society of Environmental Toxicology and Chemistry, 1993.

Federal Focus and the Institute for Regulatory Policy. *Toward Common Measures, Recommendations for a Presidential Executive Order on Environmental Risk Assessment and Risk Management Policy.* June 1991.

Fiske, Alan P. and Philip E. Tetlock. *Taboo Trade-offs: Reactions to Transactions That Transgress the Spheres of Justice.* Political Psychology (1997) 18:255-297.

Geiser, Ken, Ph.D. *Making Safer Chemicals.* Lowell Center for Sustainable Production, University of Massachusetts, Lowell, April 2005.

Geiser, Kenneth and Barry Commoner. *Materials Matter: Toward a Sustainable Materials Policy (Urban and Industrial Environments).* The MIT Press, 2001.

Government Accountability Office, Chemical Regulation: *Actions Are Needed to Improve the Effectiveness of EPA's Chemical Review Program,* 2006. Available at www.gao.gov.

Governor's Reorganization Plan No. 1. May 17, 1991.

Guth, Joseph, J.D., Ph.D. [Internet] *The Chemicals Market Cannot Generate Green Chemicals Unless the Data Gap is Closed.* Science & Environmental Health Network. 2007. Available at www.sehn.org.

Guth, Joseph, J.D., Ph.D. [Internet] *The Core Legal Test in a Chemicals Law.* Science & Environmental Health Network. 2007. Available at www.sehn.org.

Guth, Joseph, J.D., Ph.D. [Internet] *Two Rules for Decisions: Trust in Economic Growth vs. Precautions.* Science & Environmental Health Network. 2007. Available at www.sehn.org.

Hadley, O.L. et. al. *Trans-Pacific transport of black carbon and fine aerosols (< 2.5) into North America.* Journal of Geophysical Research (2007) 112:D05309.

Hawken, Paul, Amory Lovins and L. Hunter Lovins. *Natural Capitalism: Creating the Next Industrial Revolution.* Little, Brown and Company, 1999.

Herrchen, Monika and Werner Klein. *Use of the life-cycle assessment (LCA) toolbox for an environmental evaluation of production processes*. Pure Appl. Chem (2000) 72(7):1247–1252. Available at http://old.iupac.org/publications/pac/2000/pdf/7207x1247.pdf.

International Organization for Standardization. *Environmental Management - Life Cycle Assessment, Principles and Framework.* ISO 14040:1997, 14040:2006 and ISO 14044:2006.

Johnson, Branden B. and Paul Slovic. *Lay Views on Uncertainty in Environmental Health Risk Assessment.* Journal of Risk Research (1998) 1:261-279.

Kahneman, Daniel and Amos Tversky. *Choices, Values and Frames. American Psychologist* (1984) 39:341-350.

Kraus, Nancy, Torbjörn Malmfors and Paul Slovic. *Intuitive Toxicology: Expert and Lay Judgments of Chemical Risks.* Risk Analysis (1992) 12:215-232.

Lindblom, Charles. *The Science of Muddling Through.* Public Administration Review (1959) Spring:79-88.

Lovins, L. Hunter. *"Chapter 3: Rethinking Production." State of the World: Innovations for a Sustainable Economy.* The Worldwatch Institute, January 2008.

Lowell Center for Sustainable Production, University of Massachusetts, Lowell. *Framing A Safe Chemicals Future, Towards Safer Chemicals, Products, and Services.* April 2005.

Lowell Center for Sustainable Production, University of Massachusetts, Lowell. *Options for State Chemicals Policy Reform, A Resource Guide.* January 2008.

Lowell Center for Sustainable Production, University of Massachusetts, Lowell. *Presumption of Safety: Limits of Federal Policies on Toxic Substances In Consumer Products.* February 2008.

Lowell Center for Sustainable Production, University of Massachusetts, Clean Water Fund. *Safer jobs and A Sustainable Economy Through Green Chemistry and Safer Alternatives to Toxic Chemicals in California, A Constituency Analysis.* March 2007.

Matus, Kira J., Paul T. Anastas and William C. Clark. *Overcoming the Challenges to the Implementation of Green Chemistry, Working Papers, Center for International Development at Harvard University, CID Working Paper No. 155.* December 2007.

Michaels, David. *Doubt is Their Product, How Industry's Assault on Science Threatens Your Health.* Oxford University Press, April 2008.

National Academy of Public Administration, environment.gov, *Transforming Environmental Protection for the 21st Century.* November 2000.

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.

National Research Council. *Risk Assessment in the Federal Government: Managing the Process.* Washington, D.C.: National Academy Press, 1983.

National Research Council. *Science and Judgment in Risk Assessment.* Washington, D.C.: National Academy Press, 1994.

National Research Council. *Sustainability in the Chemical Industry.* The National Academies Press, 2006.

Nelson, Richard R. *The Moon and the Ghetto: An Essay on Public Policy Analysis.* New York: W.W. Norton, 1977.

Nisbett, Richard and Lee Ross. *Human Inference: Strategies of Shortcomings of Social Judgment.* Englewood Cliffs, New Jersey: Prentice-Hall, 1980.

O'Brien, Mary. *Making Better Environmental Decisions: An Alternative to Risk Assessment.* The MIT Press, 2000.

O'Brien, Mary. *What Does the Average Joe Know About Science? An Exchange.* The Networker (2000) 5:4-B.

Office of Technology Assessment. *Green Products by Design: Choices for a Cleaner Environment.* September 1992. [OTA-E-541, NTIS #PB93-101715]

Organization for Economic Cooperation and Development (OECD). *Environmental Outlook for the Chemicals Industry.* 2001. Available at http://www.oecd.org/dataoecd/7/45/2375538.pdf.

Presidential/Congressional Commission on Risk Assessment and Risk Management (CRARM). *Risk Assessment and Risk Management in Regulatory Decision-Making. Final Report, Volume 2.* Washington, D.C.: Government Printing Office, 1997.

Rossi, Mark, Ph.D., Joel Tickner, Sc.D. and Ken Geiser, Ph.D. *Alternatives Assessment Framework of the Lowell Center for Sustainable Production. Version 1.0.* Lowell Center for Sustainable Production, University of Massachusetts, Lowell, 2006.

Schapiro, Mark. *Exposed: The Toxic Chemistry of Everyday Products and What's at Stake for American Power.* Chelsea Green Publishing Company, 2007.

Sekutowski, Janine C. Greening the Telephone: *A Case Study. The Greening of Industrial Ecosystems.* 1994. National Academy Press. p. 171-177.

Silicon Valley Leadership Group. *2007 Silicon Valley Projections: Tough Challenges – Hopeful Signs,* 2007.

Simon, Julian L. *The Ultimate Resource.* Princeton, New Jersey: Princeton University Press, 1981.

TerraChoice Environmental Marketing, Inc. *The "Six Sins of Greenwashing" – A Study of Environmental Claims in North American Consumer Markets.* November 2007.

Walsh, Bryan. *"What is a Green-Collar Job, Exactly?".* Time, May 16, 2008.

United Nations, *Department of Economic and Social Affairs. World Population to 2300.* New York: United Nations, 2004. Available at http://www.un.org/esa/population/publications/longrange2/WorldPop2300final.pdf.

U.S. Department of Energy, Office of Industrial Technologies, Renewables Vision 2020, Executive Steering Group. The Technology Roadmap for Plant/Crop-based Renewable Resources 2020. 1999. [DOE/GO-10098-385] Available at http://oit.doe.gov/agriculture/

U.S. Environmental Protection Agency (U.S. EPA), Office of Research and Development. *Lifecycle Assessment: Principles and Practice.* U.S. EPA, Cincinnati, OH, 2006. [EPA/600/R-06/060]

U.S. EPA, Office of Solid Waste. *Beyond RCRA: Waste and Materials Management in the Year 2020.* U.S. EPA, 2003. [EPA 530-R-02-009]

U.S. EPA, Office of Solid Waste and Emergency Response. *WasteWise Update: Environmentally Preferable Purchasing.* U.S. EPA, 2001. [EPA 530-N-01-002]

White House Council on Environmental Quality, *The Twenty-fifth Anniversary Report of the Council on Environmental Quality.* 1997.

Wilson, Michael P., Ph.D., Daniel A. Chia and Bryan C. Ehlers. Special Report. *Green Chemistry in California: A Framework for Leadership in Chemicals Policy and Innovation. California Policy Research Center,* University of California, 2006.

Wilson, Pete, Governor. *Annual Environmental Report and Message of the Governor,* 1997-1998. California Environmental Protection Agency, January 1998.