Comprehensive Chemicals Policies for the Future

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The origins of our national chemicals policies trace their roots back to the 1970s when leaders in Congress fashioned a framework of federal laws that set regulations on chemicals in air emissions, water effluents, products and wastes. With this framework largely constructed in 1976, Congress enacted the Toxics Substances Control Act (TSCA) as a general "catch all" statute to directly regulate chemicals where they present an unreasonable risk.

Although TSCA provides broad powers to the federal Environmental Protection Agency (EPA) regarding chemical notification, testing, market entry, restrictions and record keeping, it has been largely regarded as a failure. While there have been many government and private evaluations, Government Accounting Office critiques and Congressional oversight hearings, TSCA has never been redrafted or amended. Many reasons have been put forward for TSCA's poor performance ranging from poor management, conflicting requirements, and overly tough burdens of proof to the intense hostility of the chemical industry.

The purpose of this paper is to present a sketch of a very different approach to chemicals policy than that constructed in the 1970s. The passage of time has allowed us to recognize the flaws and limits of the conventional approach. Now, some forty years beyond the 1970s we have arrived at a good point to reconsider and redesign the nation's chemical policies. In the next few years we will have an opportunity to change what has already been constructed. Whether we choose to do that through modest adjustments or a substantial overhaul depends upon our capacity to think broadly and boldly about how we frame the chemicals in society problem and how much we what to innovate and alter what has become the conventional practices of the day. This paper suggests that our ambitions should be bold.

Flaws in Federal Chemicals Policy

In order to fully understand the limits of current federal chemicals policy it is worth stepping back to look at the broader complexity of chemicals policies of which TSCA is merely one part. With the value of hindsight much can be seen and now questioned about the assumptions and principles that were built into the chemical policy framework constructed by the Congress during the 1970s.

Chemical policies need only focus on the most dangerous substances. The political philosophy of the period respected the sanctity of the market and reserved government intervention only to those areas where the market was failing to respect commonly held values such as health and safety. Industrial chemicals and consumer products long on the market were presumed to be acceptably safe. This meant that most industrial chemicals on the market—the existing chemicals-- were not candidates for government regulations and regulators could more effectively spend their efforts on the small number of truly dangerous substances.

Chemicals were addressed outside of their function. A basic assumption of the chemical policies of the 1970s was that chemicals could be addressed largely divorced from their many functions in production processes and products. Today we understand that chemicals are synthesized and manufactured in integrated systems of production and they are selected and designed for specific applications that are dependent on them. Mercury is an off product in processing coal; copper, zinc and lead are often fond together as sulfides in the same ores; ethylene glycol, styrene and vinyl chlorine are all co-produced from ethylene; lead and phthalates are used as plasticizers to soften PVC; the huge surpluses of sulfur from desulfurization makes sulfuric acid inexpensive and available to make other acids. Efforts to reduce the use of one substance in one application can have significant effects on the market resulting in changes in the use of other chemicals which can further effect the processing of even other chemicals.

Chemical policies addressed chemicals one by one. Locked into the early statutes was a one by one orientation towards hazardous chemicals. Chemicals were to be tested one by one and individual compounds were to have individual standards. There was little attempt to view chemicals in terms of the complex interactions that chemicals have when released to the environment or to the synergistic mix of substances that actually make up a human exposure. Most environmental advocacy organizations, the media and the public followed this singular focus with sequential initiatives on specific compounds like DDT, 2,4 D, polychlorinated biphenyls, dioxin, asbestos, mercury, lead and brominated flame retardants even though it was recognized that no one is ever exposed to one chemical at a time and chemicals in commerce are seldom pure and unique.

Chemical policies were fragmented with varied requirements for chemicals in wastes, emissions, workplaces and products. Different approaches were taken to regulating chemicals in the Clean Air Act, the Clean Water Act, OSHA and the pesticide statute. Rather than draft TSCA as an omnibus framework for coordination among these exposure reduction statutes, TSCA was required to defer to other statutes and function only where other laws provided inadequate protection. Thus, authority over chemicals is prescribed by over 20 statutes and divided among some 12 federal agencies and, even within the EPA, there are separate sections for air, water, wastes and chemicals.

Chemical policies were based on inadequate information on chemical uses, hazards and exposures. For most chemicals there has never been adequate information for adequately characterizing their hazardous properties or their fate and transport in the environment. TSCA provides the government with authority to collect studies of the health and environmental effects of existing chemicals, but until this last decade there was little initiative to do so. Under TSCA the EPA has authority to require testing, but over the past forty years the agency has required testing on less than 200 substances. The Centers for Disease Control has only begun to collect biomonitoring data on chemicals in human fluids in the last decade, and only tracks some 148 chemicals. An even bigger data gap involves the lack of information on where and how chemicals are used in the economy. There is no product constituent reporting system, no chemical transport tracking system, no chemical processing inventory, and no chemical production data other than what is collected every five years on only the largest volume chemicals.

Chemical policies focused primarily on risks. Focusing on risks has an important place in setting priorities for government or corporate interventions to promote safety and health. However, a focus on risk in seeking acceptable levels of safety often encourages exposure management rather than reduction of intrinsic hazard and leads to investments in engineering controls, management systems, restrictive regulations and compliance monitoring and enforcement. Real exposures over the lifecycle of a chemical are often hard to confidently predict and a trust in exposure control gives comfort to the idea that chemicals are always "properly used". Rather than expensive controls a better investment strategy involves efforts to discover, design and adopt less hazardous substitutes. Because hazard is intrinsic it is easier to assess than exposure and, therefore, less dependent on site or time specific conditions and more likely to reveal chemical characteristics for more consistently improving health and environmental compatibility.

Chemical policies used "sticks" without "carrots". Because the chemical policies of the 1970s developed out of a need to protect health and the environment they were designed to limit, restrict and prohibit chemical uses, releases and exposures. The government is cast in a police role setting conditions on what not to do. Setting boundaries, limits and conditions is an important role, however, it has never been balanced by parallel functions that reward and encourage safer and more sustainable technologies and practices. Indeed, there has been little incentive for safer chemical innovation and green chemistry research. The Presidential Green Chemistry Challenge Program and Design for the Environment are among the few EPA programs that promote research and development of safer technologies.

Lessons from Forty Years of Federal Chemicals Policy

The history of chemicals policy reveals many limits. Still it is important to recognize that government agencies and progressive corporations did try hard and that there were many successes: air quality improved; drinking water is safer; many carcinogens are better controlled; a small number of truly dangerous substances are no longer manufactured or widely used. However, a broader picture reveals lessons that could help shape future chemicals policies. These include:

Focus on all chemicals—not merely hazardous chemicals. The central focus on highly hazardous chemicals has left most chemicals unstudied and unaddressed, supported the assumption that only a few chemicals offer real threats, and led to a negative and prohibitive policy approach that relegates governments to policing markets and firms satisfied with maintaining compliance.

Require full chemical characterization--- not merely MSDSs. Until recently a large number of high volume chemicals in commerce have continued to be used with little and often no data on the hazards that they pose. Even today, some 50-70,000 lower volume chemicals are used with next to no hazard profiles. Even where data is available, access to that data is difficult and seldom available at the many points where decisions are made to use or release chemicals or to expose people.

Substitute Safer Alternatives---rather than Regulate Exposures. Regulating exposures focuses attention on engineering and administrative solutions that manage threats at one moment in time. Focusing corporate, government and public attention on the development and adoption of safer alternatives more fundamentally reduces hazards over the lifecycle of a chemical by building markets for inherently safer and more sustainable alternatives.

Penalize Laggards---rather than Encumber Leaders. We focus significant government and public attention on the larger and better managed companies. Too often, smaller and off-shore firms are the leading culprits in creating pollution, waste and dangerous workplaces. We need to focus more on weaker and less responsible firms and reward good company performance. Recognizing leadership is valuable because it creates models for emulation and legitimates sanctions against those who lag in environmental performance.

Invest in Designing Safer Chemistries—rather than Studying the Most Dangerous. Vast amounts of public and private research investments have been dedicated to studies and counter studies of the health and environmental effects of a relatively small number of chemicals, while far less research has explored what makes chemicals safe and how to make more of them safe.

Source Renewable Feedstocks---rather than Petrochemicals. Synthesizing and using petroleum or coal derived chemicals ties chemical production to fuel production, requires substantial energy inputs, lowers chemical costs such that wastes are inevitable, and consumes non-renewable planetary resources. We need a bold new research program on chemicals derived from renewable sources, such as plants, air and water, and non-food agricultural resources.

Conserve Energy and Resources—rather than Generate Wastes . Chemical manufacturing and processing is one of the most energy intensive sectors of the national economy. Mining and chemical production generates the largest volumes of hazardous wastes in the country. Heavy investments in waste reduction, yield improvement and low heat, low pressure, ambient processes could conserve large amounts of materials, energy and costs.

Chemicals, Materials, Products, Systems

Chemicals do not stand alone. They are constituents of materials, parts of products and embedded in systems. We need to understand that chemicals, the chemical industry and the economy are all intertwined in a complex set of systems and sub systems such that changes—even quite minor changes, like closing down the manufacture of a chemical—can have broad and sometimes quite indirect effects throughout the system. We need to develop models for policy interventions that respect the highly integrated and systemic ways in which chemicals function in the economy.

This is re-framing: moving from a focus on single chemicals to a focus on systems of chemical production, use, and disposal, on families of chemicals, on sets of functions and on collections of firms. This means better understanding chemical and material production and use systems in order to understand critical leverage points that either inhibit or lead to change. This means paying closer attention to chemical markets and to the financing and investing in chemical manufacturing. This means working more broadly through supply chains, organizing and encouraging dialogues along the value chain whereby customers can talk to and plan with chemical suppliers, processors and manufacturers. And, this means a different orientation of government: one that respects the power of government to regulate, but enlarges the role of government as a facilitator, information source, technical assistant and promoter.

A systems approach more clearly recognizes the role of chemical distributors, product retailers and large institutional product purchasers. Markets are driven by customer desires, however, in large complex societies, individual domestic customers have next to no influence over what they can or do purchase. It is comforting to note that some modest number of shoppers (maybe 10 to 12 percent) will seek products with health or environmental attributes. However, the primary decisions about what domestic customers buy are made by retailers and distributors who select small numbers of products to put before customers and by large institutional buyers who exert significant purchasing power on markets by buying in bulk. From this perspective, the real forces of consumer choice are located not with "mom and pop" harassed by media advertising, but in the decisions of institutions such as Wal-Mart, Staples, Carrefour, Consorta, Novation, Univar, Ashland Distributors, and the Pentagon. If we are to move towards safer chemicals and technologies, distributors, retailers and large buyers must play a significant role in implementing chemicals policies.

Moving towards safer chemicals within systems of production, distribution, use and disposal requires an understanding of life cycles. Chemicals flow through manufacturing and use systems and chemicals are disposed through system losses (dissipation) and through end-of-life processing, destruction and internment. Life cycle considerations open up a more complete view of chemical relationships and the many points where a given chemical may create threats to human health or the environment. Life cycle assessment is a new formalized tool for such assessments, but, often, a simpler, more informal life cycle map or inventory may provide the necessary perspective.

By considering chemicals in systems, supply chain dialogues and life cycle maps we can lay the foundation for a new, more comprehensive approach to chemicals policy.

Goals and Objectives for Chemicals Policy

In considering chemicals policy for the future a good starting point is its goals. The "Swedish Environmental Quality Objectives"[*] laid out in 1997 and formally adopted in 1999 provide a fine example of objectives that can be clearly stated, discretely measured, and periodically assessed to determine degree of achievement.

Among the 15 environmental quality objectives is one focused on the achievement of a "non-toxic environment":

[*] Swedish Parliament, Government Bill 1997/98:145, 1997.

> "The environment must be free from man-made substances and metals that represent a threat to health or biological diversity. This means that:
> - the levels of substances that occur naturally in the environment must be close to background levels,
> - the levels of man-made substances in the environment must be close to zero."

To achieve this objective, the Swedish government issued guidelines on chemicals policy to assist companies in their product development and chemical strategies and to aide government agencies in implementing the National Environmental Code.

> 1. New products introduced into the market are largely free from:
>   - man-made organic substances that are persistent and liable to bioaccumulate, and from substances that give rise to such substances,
>   - man-made substances that are carcinogenic, mutagenic and endocrine disruptive – including those that have adverse effects on the reproductive system,
>   - mercury, cadmium, lead and their compounds.
> 2. Metals are used in such a way that they are not released into the environment to the degree that causes harm to the environment or human health.
> 3. Man-made organic substances that are persistent and bioaccumulative occur in production processes only if the producer can show that health and the environment will not be harmed.

The Swedish Objectives offer a good model for national goals. In a clever side step, the Swedish government avoided the difficult to define issue of toxicity, instead implying that a chemical system that is free of harm to the environment or human health must by definition be "non-toxic".

In this country we are more comfortable with our definitions of hazard and risk. So we may want to fashion a national goal for an environment free of unnecessary chemical hazards with a priority given to those substances that pose the highest risks. However, we frame a national goal it is important that it be broad and comprehensive. If nothing else should differentiate our new programs from those of the past, we should seek to be comprehensive. We will never achieve a sustainable chemical system or a "toxic-free environment" if we do not address all chemicals and chemicals in a systemic and holistic manner.

Six Elements of a Comprehensive Chemicals Policy

What can be meant by comprehensive chemicals policies? A simple definition would be: "….comprehensive, integrated and prevention-oriented policies designed to achieve the development and use of non-hazardous and sustainable chemicals in production systems and products."

Comprehensive chemicals policies may be government policies or corporate policies. The newly adopted REACH Regulation in the European Union is an impressive example of a comprehensive chemicals policy. However, there are an increasing number of firms that are instituting across the board chemicals policies that cover all of the substances in their production processes or, alternatively, all of the substances used in an industrial facility from feedstocks to toilet cleaners. Examples include firms such as Nike, Herman Miller, Interface, Volvo, S. C. Johnson, and United Technologies.

While there are variations among these emerging examples of comprehensive chemicals policy, there are six primary characteristics that form a defining framework. These are:

1. Comprehensive chemicals policies are inclusive and comprehensive. They cover all chemicals—toxic and hazardous substances, as well as, substances that are relatively benign. In practice, most of these examples of chemicals policy focus on so-called "industrial chemicals" and do not include chemicals such as biocides, pharmaceuticals, cosmetics, foods, and fuels

2. Comprehensive chemicals policies categorize chemicals into groupings or tiers. These tiers range from substances that are undesirable and should be avoided to those that are preferred. These categories typically are based on degree of concern with a pinnacle of substances of significant concern differentiated from substances of lesser concern, substances of unknown concern, and substances of little concern.

3. Comprehensive chemicals policies are hazard- rather than exposure-based. Risk consideration may be used to initially screen chemicals or to set priorities, but the intrinsic hazards of a chemical not the potential for exposure is the primary consideration in determining the preference of a chemical.

4. Comprehensive chemicals policies are intended to create and open access to information. Information is critical to making informed judgments. There is a significant need for more research on the environmental and human health effects of the chemicals commonly manufactured and used, especially, the thousands of substances used in small quantities. However, the generation of this data has no public value if it is not made transparent and openly available. The validity of science is only as good as the openness with which its results can be shared, reviewed and evaluated.

5. Comprehensive chemicals policies are intended to transition chemical use from high hazard to low hazard substances. These policies are not intended as passive 'maps" of chemical use; they are created and used to drive and guide chemical substitutions in manufacturing and product design. A balanced array of incentives and disincentives with goals and timetables backed by the prospect of regulations allows for a well-informed and planned approach to substitutions that minimize unintended consequences.

6. Comprehensive chemicals policies are intended to promote research and innovation. These initiatives are expected to push the development of safer and more environmentally-compatible chemicals. As a consequence these policies serve as drivers for better chemical data collection and more science to develop new, safer, and more effective chemicals—chemicals that need to be developed and synthesized through green chemistry principles.

A Comprehensive and Inclusive Approach to Chemicals

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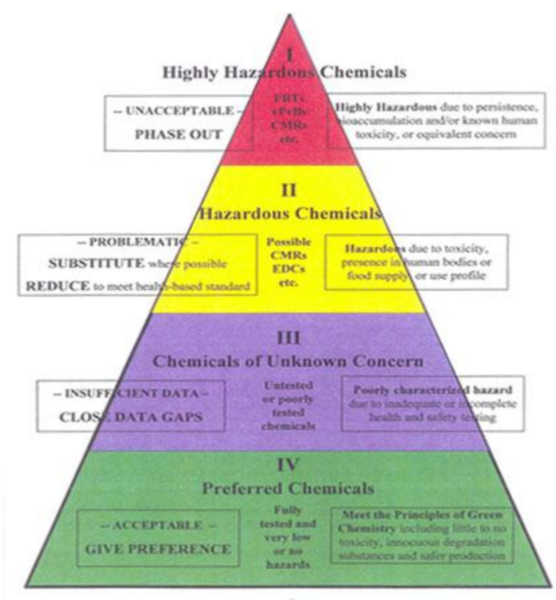
A comprehensive approach to chemicals policy needs to address chemicals in a holistic and systemic approach. We need to consider the whole body of synthetic and manufactured chemicals. There are many chemicals that are relatively safe and perform multiple functions well, while there are others that are unacceptably dangerous even if their performance is exceptional. As a baseline, we need to develop a comprehensive inventory of chemical substances that is broad, inclusive and universal.

The chemical industry is one of the largest industries in the world. It produces some 100,000 to 140,000 chemical substances. A relatively small number of products (some 2500) account for most (roughly 95%) of the production volume. Large portions of the total volume consist of synthesis intermediaries and fuels. However, we do know what these chemicals are. We can identify and inventory them.

Unlike a half century ago, we now have a broad enough understanding to know what types of chemicals and families of compounds are more or less likely to be hazardous. For many substances, particularly the heavy metals, the halogens and the aromatic hydrocarbons we have substantial scientific laboratory-based and epidemiological study of their hazardous attributes. Structure/activity analysis and "read across" tables provide tools for estimating the likely hazards of chemicals that exhibit certain common chemical structures when scientific studies are absent With this knowledge we could develop categories in a broad inventory of chemicals that locates substances as to their hazardous properties. There are many databases that list chemicals of greatest concern including the International Agency for Research on Cancer's list of carcinogens, the U.S. National Toxicological Program list of carcinogens, the European Commission's list of substances of very high concern, Washington State's list of persistent, bioaccumulative and toxic chemicals, and the Oslo-Paris Convention for the Protection of the Marine Environment of the North East Atlantic list of chemicals for priority action. The Swedes and Danes have developed screening protocols for classifying chemicals based on degree of concern. The Canadians have completed a monumental effort to screen all of the principle chemicals used in Canada and classified some 4000 substances as high hazard. The United Nations Globally Harmonized System of Classification and Labeling of Hazardous Substances also provides a useful frame for classify chemicals.

We need to develop a **Comprehensive Categorization of Chemical Substances** that arrays all chemicals into some criteria-defined set of tiers. An example presented here[†] sets up four tiers: Highly Hazardous Chemicals, Hazardous Chemicals, Chemicals of Unknown Concern, and Preferred Chemicals. It is presented as a pyramid to suggest that the number of chemicals in the upper, undesirable tiers is less that those that are preferred or those that are simply un-assessed. Given the general objective for a non-toxic environment it is expected that some 1000-1400 substances should be candidates for highly hazardous category with some 200-300 expected to be persistent and bioaccumulative



Such a categorization not only helps to clarify what we do and don't know about chemicals in use, but it also lays out a framework for transitioning from the top tier to lower tiers. It further identifies where science and research should be targeted. It is clear what substances are unstudied and where we need to invest in research for safer, more desirable chemicals.

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† Mark Rossi, Laurie Valariano and Michael Belliveau, *Framework for Chemical Policy Reform*, unpublished, 2006.

Develop More and Better Chemicals Information

A comprehensive chemicals policy requires scientifically valid and reliable information on the manufacture and use of chemicals, on chemical hazards and on the potential for chemical exposure. Generally, there are three areas for information development. These include:

- *Information on the inherent characteristics of chemicals*. In order to properly locate a chemical in a Comprehensive Classification we need to develop **Chemical Profiles** for every chemical on the market. A Chemical Profile should include a base set of data including the physical/chemical characteristics, the toxicological properties, the biological behavior, including the potential to enter, persist, accumulate and metabolize in living organisms, and the fate and transport characteristics in the environment

- *Information on the production, use and lifecycle of chemicals*. In order to understand how chemicals appear, move, change and disperse in the economy we need information for each chemical on manufacture, importation, distribution, use and disposal. Such information can be presented in the form of national surveys or registries. While surveys may do well on production and importation data, registries may be better suited to cataloguing information on use and disposal.

- *Information on release and exposure of chemicals*. In order to understand threats from chemicals and to prioritize attention and interventions we need information on the actual release and exposure of chemicals, the potential for release and exposure, and the presence of chemicals in environmental media, humans and other organisms.

There are many ways to develop this information that includes government laboratories, universities, professional associations, and corporate research facilities but the responsibility for assuring that this information is generated and made available needs to rest with the chemical supplier—the manufacturer, importer, distributor or vendor. Generating this information can be costly and chemical manufacturers are best positioned to bare those costs and then to pass them on in the price of products. Only by making the supply of sufficient information the responsibility of the chemical supplier can the true cost of a chemical be priced in the market. Thus, bringing a chemical to market or maintaining it on the market involves both providing the substance as well as the information that permits the substance to be safely used.

Our past experience demonstrates that conventional market incentives will not guarantee that adequate chemical information is generated or made available for all chemicals. A comprehensive approach to chemical policy will require a formalized requirement that access to the market is contingent on delivery of a Chemical Profile and its associated chemical information. The European Union's REACH regulation provides a good model for this with its "no data, no market" requirement that sets a definitive date for determining when market access will be closed.

The collection and management of the information provided by chemical suppliers is a legitimate function of government and, therefore, a comprehensive chemicals policy should include a system of public and Internet-based **Libraries of Chemical Information**. The function of such a system of libraries should be to assure that chemical information is stored and catalogued for ready access, periodically validated through independent audits, and made accessible through common electronic portals.

Address Chemicals by Economic Sector

A comprehensive approach to chemicals policy needs to be respectful of the systemic nature of chemical development and use and more understanding of the way markets function and technologies enter, diffuse and succumb within markets. The 1970s approach that relied on government restrictions and prohibitions tried to extract chemicals from the economy for individual regulation and proved ineffective. We need to think less about restriction and more about conversion.

The market is a dynamic environment built up of complex systems that determine what is produced, what is sold and what is used. If we want to successfully introduce health and environmental values into the market and transition dangerous practices and technologies to safer ones we need to make dangerous chemicals undesirable and encourage the development of more preferred substances.

We can best do this within the context of economic sectors. While the economy is an integrated system it is composed of inter-connected subsystems and we know some of these as "sectors"—the automotive sector, the agricultural sector, the electronics sector. By focusing on sectors we can more directly see chemicals embedded within the context of their use and more quickly identify alternatives for substitution or functions that can be reconfigured to alter the chemical requirements. From this perspective chemicals, like communications or finances provide a kind of "platform" upon which economic sectors are built and depend. Sufficient and appropriate communications, finances or chemicals are necessary to make a sector productive.

From an environmental and health perspective our productive economic sectors are seen to be built on inappropriate chemistries. What we need are programs that transition economic sectors from current chemistries to more sustainable chemistries. Indeed, the environmental advocacy community has been working over the past decade within some sectors to change chemistries and these campaigns have demonstrated fairly successful transitions. The chemistries of the personal care products sector are being transformed by a market campaign focused on safer cosmetics. The products of the electronics sector are being transformed by "take back" campaigns and the European Union's and China's directives on waste electronics and restricted substances. The health care sector is being converted to safer chemistries by Health Care without Harm. Just as impressive is the way in which Wal-Mart and other progressive retailers are changing the chemistries of consumer products. There are important lessons here.

A comprehensive chemicals policy should be built around the conversion of economic sectors. Programs need to be set up in targeted sectors with the objectives of moving the chemical use and material flows in that sector to safer and more sustainable chemistries. Efforts to phase out hazardous chemicals and substitute safer alternatives make sense within a sector because there is an economic and technical logic to how specific chemicals are used within a given sector (and that logic might be quite different in another sector). Safer alternatives are more readily diffused where early adopters within a sector model behavior for later adopters. Working within sectors offers opportunities for multiple objectives. Efforts to work within a sector to convert the sector on chemicals can parallel efforts to convert that same sector on carbon emissions, water consumption or workplace rights and reduce concerns that these are competitive objectives.

How would sector conversion strategies work? The government establishes a **Sustainable Sectors Program**. Program leaders, such as leading firms, trade associations, public interest organizations, and significant market players, are assembled to design a conversion strategy. The program leaders work with the government to create strategic **Sustainable Sector Roadmaps** that identify the stocks and flows of materials and chemicals, analyze the functions that these substances play in the production systems, assess these substances against the preference tiers in the "Comprehensive Categorization of Chemical Substances", set goals and objectives, and begin to develop a set of positive and negative pressures to encourage substitution of lower tier "preferred alternatives".

Working within sectors allows for the critical dialogues among firms within supply chains that encourage cooperative and integrated changes such that suppliers and customers jointly transition to new chemicals and develop new practices that set up new relationships within existing market systems. The actual strategies and tools employed promoting conversions need to be tailored to the specific conditions and values that drive particular sectors, such that a specific mix of economic incentives, trainings, technical assistance, investments and regulations used in one sector might be different in another sector. However, the goals of each sector program are similar: reduce hazardous substances and processes while building economically viable, productive, sustainable and internationally competitive industries.

Promote Green Chemistry and Engineering

A comprehensive chemicals policy should focus as much on the lower tier preferred chemicals as on the upper tier higher hazardous chemicals in the "Comprehensive Categorization of Chemical Substances". Today, there simply are not enough alternative substances in the lower tier to serve as effective substitutes for chemicals of high concern. One leading green chemist claims that 65 percent of hazardous chemicals do not have green chemistry alternatives. Without more and better green chemicals and green engineering solutions conversions to safer alternatives within the "Sustainable Sectors Programs" will not succeed.

The problem here is not only the absence of enough research in this area; there are not enough researchers. The number of chemists graduating from conventional higher education chemistry programs has been declining for years. The number of green chemistry or green engineering programs in colleges and universities remains limited.

The government should establish a **National Green Chemistry and Engineering Initiative** with the enthusiasm and resources that it used to launch the Apollo Project. Such an initiative could be modeled on the National Nanotech Initiative that today offers over a billion dollars in research support annually through ten cooperating federal agencies. This new initiative should provide:

- *A federal extramural research program.* A bill has been languishing in Congress for four years that would provide modest funding for green chemistry research. This bill should be significantly expanded in scale and broadened to include support for bio-processing and bio-based materials development based on non-food, agricultural resources.
- *Regional green chemistry and engineering centers.* The state pollution prevention initiatives demonstrated the importance of regional technical assistance centers that can work directly with individual facilities trying to adopt environmentally preferred practices and technologies. Funding for some ten or more green chemistry and engineering centers that could involve consortia of universities, community colleges,

state agencies and professional organizations could offer critical facilitation services in helping smaller firms adopt inherently safer chemicals and technologies.

- *Aide to colleges and universities establishing green chemistry and engineering educational programs*. The National Institutes of Health offer financial support for various graduate training programs to increase the number of well trained health care specialists. These programs could serve as models for encouraging and supporting chemistry and engineering departments in creating new curriculum and supporting students engaged in undergraduate and graduate green chemistry and engineering programs.
- *Federal leadership in Green Chemistry and Engineering*. Promotional and supportive federal programs such as the Presidential Green Chemistry Challenge and the EPA's Design for Environment Program should be expanded and more closely integrated with state green chemistry programs like those recently launched in Michigan and California.

Redesign the Role of Government

Government can play a central role in transitioning our economy to safer and more sustainable chemistries. This will require that government agencies expand the ways they that they work with chemical and product manufacturers. Government leaders will need to respect the complex and highly interdependent way that chemicals, users, suppliers, and manufacturers are connected through the chemicals market and act more like acupuncturists carefully intervening only at the most important leverage points. Sometimes all this will take is raising awareness, awarding innovators or convening stakeholders; at other times, it will take training, direct assistance and economic encouragement: and, at still other times, it will take a bigger stick. Three functions of government that are important for promoting comprehensive chemicals policy are guidance, investment and regulation.

Guidance. The federal government should create a broad vision for a **National Sustainable Economy Strategy** that lays out plans, set goals, establish timelines and monitor and report on progress in moving the United States towards a more sustainable future. Within this framework government leaders should convene the Sustainable Sectors strategy sessions that are needed to create the sector specific roadmaps for converting economic sectors and manage the cross sector planning that serves to coordinate the sectoral conversions. The comprehensive inventory of all chemicals tiered by level of hazard should be maintained by government authorities as should the maintenance of the chemical information libraries.

Investment. Government support for basic science is needed in three areas: first, to build the scientific platforms for green chemistry; second, to develop the toxicological and pharmacological understanding of how chemicals affect the environment and public health; and, third, to develop the tests and methods needed for determining the hazardous characteristics of chemicals. Public resources are needed to promote green chemistry and engineering curriculum development and education programs at the higher education level, to create stipends and awards that encourage student engagement, and to support innovations in chemistry teaching at the primary and secondary educational level.

Government investments can further advance the transition to safer chemistry by promoting and implementing preferred government and institutional procurement policies, product certification and labeling programs, and public awareness.

Regulation. Regulations set the boundaries for acceptable market performance. Regulations are needed to prohibit the most irresponsible practices; to drive externalities such as emissions, wastes and exposures back into the proper pricing of chemicals; and to level the market playing field so as to discourage laggards from benefiting from their lagging. Regulations always change markets and, when regulations are properly designed, markets can and do respond with innovations. Experience with the prohibitions on polychlorinated biphenyls and asbestos demonstrated how regulations can drive innovation particularly where the regulations are clear, forceful and announced well in advance. But regulations can also encourage market innovation more indirectly by requiring public reporting, substitution planning, and product labeling. Massachusetts's Toxics Use Reduction Program and California's Proposition 65 provide useful examples.

However, poorly designed and enforced regulations can discourage compliance, lead to costly government policing, and stall innovation. The best outcomes come where regulations are paired with non-regulatory technical assistance, option development and capacity building. In this view, government regulations share two compatible objectives: protect the public from dangerous exposures and direct the market towards safer substances.

Governments, too, are composed of inter-related systems and they can only function well when they are well coordinated and consistently focused on concrete goals with real timetables. With so many different federal and state agencies overseeing chemicals policy, this may require new integrative structures at the federal level.

Develop a New National Chemicals Agency

A comprehensive approach to chemicals requires a coordinated approach to chemicals that seeks to harmonize chemical information generation, regulation and promotion. For this, it is reasonable to consider the need for a new central chemicals agency to promote cooperation and reduce inefficiencies. The Swedish Chemicals Agency (KemI) in Sweden and the new European Chemicals Agency in Helsinki offer interesting models of non-regulatory government divisions that oversee chemical information.

Such a new federal agency could be a non-regulatory division that serves as a focus for collecting the "Chemical Profiles", developing and managing the "Chemical Categorization of Chemical Substances" and coordinating the databases distributed through the "Libraries of Chemical Information". In addition, the chemicals agency could serve to coordinate funding for the "Green Chemistry and Engineering Initiative" to promote new chemistry and engineering curriculum.

Models of Governmental Chemicals Agencies

Swedish Chemicals Agency (KemI)

KEMI Swedish Chemicals Agency

KemI is a supervisory authority under the Ministry of the Environment that works in Sweden and in the European Union to promote legislation and rules that contribute to achieving "a non-toxic environment". KemI keeps a products registry, maintains chemical hazard databases, approves pesticides, assesses the risk of chemicals, checks companies´ compliance with applicable regulations, provides support to local authorities and maintains statistical information on chemicals.

European Union: Chemicals Agency

ECHA

The new European Chemicals Agency's mission is to ensure consistency in chemicals management across the European Union and to provide technical and scientific advice, guidance and information on chemicals.

A new chemicals agency does not replace the current regulatory agencies responsible for chemical management and regulation. Rather a new central agency would offer a parallel entity that serves as a focal point and resource for government coordination and sustainable chemical promotion.

Comprehensive Chemicals Policy for the Future

If we are to achieve a sustainable economy in the United States we will need a dramatic overhaul of the ways in which we handle chemicals, materials and energy. The environmental leaders of the 1970s established through federal statutes an array of chemicals policies that have done much to manage dangerous chemicals in air, water and workplaces. However, there is a broad gap between our current status and the goals of a "non-toxic environment". To achieve this we will need major revisions in our current policies.

We could try to adjust, correct and incrementally improve our current policies. We could try to reform TSCA. However, it will take substantial efforts because so much investment has been made in the conventional framework by corporations, by governments, and by the environmental advocacy community. Rather than struggle to reform TSCA and the other chemicals management laws, it would be better to work for a major overhaul based on a different understanding of the chemicals problem and a different perspective on the solutions. By locating the chemicals in society problem within a larger economic systems perspective, solving chemicals problems is as much about developing a just and sustainable economy that provides new investment opportunities, new businesses and new jobs as it is about protecting public health. This is the task that the Europeans set out in 2001 with the release of the White Paper that called for a comprehensive overhaul of European Union chemicals policy.

We could set about to work for a truly comprehensive chemicals policy built from a systems perspective that sought to phase out the most hazardous chemicals by substituting them with safer alternative chemicals and technologies some of which will require more research and development to become available on the market. This is a different, but compatible approach to conventional chemical control policies. It may appear like an overly ambitious mission. However, if we cannot envision it, if we can not debate it and develop it, we will never achieve it. Now is a good time to start that process.