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Features – Changing Policy

REDESIGNING CHEMICALS POLICY: A VERY DIFFERENT APPROACH

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ABSTRACT

The chemical policies of the 1970s were limited by the assumptions that lie at their foundation and focused narrowly on only the most hazardous chemicals. The effective management of chemicals requires policies that focus on the entire body of chemicals and the production systems that make them. The future will require comprehensive chemicals policies that work within a systems framework to phase out the most hazardous chemicals, progressively transition away from the remaining chemicals of concern by substituting safer chemicals and technologies, and invest heavily in a new generation of safer and more sustainable chemicals.

Keywords: chemicals policy, hazardous chemicals, systems thinking, green chemistry

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, liquid effluents, products, and wastes. With this framework largely constructed, in 1976 Congress passed the Toxics Substances Control Act (TSCA) as a general "catch-all" statute to regulate chemicals directly wherever they present an unreasonable risk [1].

Although TSCA provides broad powers to the Environmental Protection Agency (EPA) regarding chemical notification, testing, market entry, restrictions, and recordkeeping, it has been largely regarded as a failure. While there

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have been many government and private evaluations, Government Accountability Office critiques, and Congressional oversight hearings, TSCA has never been redrafted. Many reasons have been put forward for TSCA's poor performance, ranging from poor management, conflicting requirements, limited resources, and overly tough burdens of proof to the intense hostility of the chemical industry [2].

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 40 years beyond the 1970s, we have arrived at a good point to reconsider and redesign the nation's chemicals policies. 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 problem of chemicals in society and how much we can overcome the substantial commitment to conventional practice. This paper suggests that our ambitions should be bold.

FLAWS IN FEDERAL CHEMICALS POLICY

In order to understand fully the limits of current federal chemicals policy, it is worth stepping back to review the broader assumptions that were built into TSCA and other laws intended to directly control chemicals, such as the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) [3] and the Consumer Product Safety Act (CPSA) [4], which taken together, round out the basic framework for the nation's chemicals control policy. With the value of hindsight, much can be seen and now questioned about the assumptions and principles that were built into these laws.

Chemicals policies focused only on the most dangerous substances. With a strong belief in the market, the legislators who drafted the laws limited government intervention only to those areas where the market failed to protect public or environmental health. Industrial chemicals and consumer products long on the market were presumed to be safe. The pesticide law's presumption that a pesticide is dangerous was inverted by TSCA to mean that most industrial chemicals on the market—the existing chemicals—were not candidates for government regulations. This presumption of safety was even more pronounced under the consumer products law, where existing products were assumed to be safe until some study or incident proved otherwise.

Chemicals policies addressed chemicals one by one. Locked into the early statutes was a one-by-one orientation towards hazardous chemicals. While TSCA provided authority to restrict the manufacture and use of chemical groups or mixtures, in practice the EPA maintained a chemical-by-chemical approach that focused on the identification, testing, and management of individual substances. This same narrow focus pervades the pesticide and consumer product safety laws. When the Consumer Product Safety Commission considered the hazards of phthalates in toys, it did so without addressing the potential hazards of other substances in toys such as lead, pesticides, or flame retardants or addressing their aggregate consequences.

Chemicals policies were fragmented with diverse requirements for chemicals in wastes, emissions, workplaces, and products. The separate chemical control laws covering pesticides, industrial chemicals, and chemicals in products differ in their coverage and authorities and differ further from the media-specific environmental protection laws. Rather than being drafted as an omnibus foundational framework for supporting and coordinating these statutes, TSCA was designed 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 15 federal agencies, and even within the EPA there are separate sections for chemical emissions for air, water, and wastes.

Chemicals policies focused on limiting adverse chemical exposure rather than addressing the inherent hazards of chemicals. Focusing on risks was central to each of the chemical laws. However, a focus on risk in seeking safety often encourages exposure management and engineering controls rather than design changes that reduce or eliminate the need for hazardous chemicals. Unlike a focus on eliminating the intrinsic hazards of a process, a risk focus requires lengthy efforts to predict dose-responses and potential human exposures. However, real exposures over the lifecycle of a chemical are often hard to predict confidently, and a trust in exposure control gives comfort to the idea that chemicals are "properly used."

Chemicals policies used "sticks" without "carrots." Because the chemicals 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. Setting restrictions was seen as the paramount government role; however, it was never balanced by parallel functions that reward and encourage safer and more sustainable technologies and practices. By focusing solely on the worst substances, government agencies were provided little authority or capacity to fund research, provide incentives, or otherwise promote safer alternatives and greener chemistries.

CHEMICALS, MATERIALS, PRODUCTS, SYSTEMS

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

This requires reframing the conventional definition of the chemicals problem: 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 of chemical and material production and use systems in order to identify critical leverage points that either inhibit or lead to change. This means paying closer attention to chemical markets and to financing and investing in chemical manufacturing. This means working more broadly through supply chains 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, there are long chains of suppliers that determine and narrow the range of products from which consumers can select. Increasingly, large retailers, government agencies, and institutional group purchasing organizations are negotiating with suppliers for products free of chemicals of high public concern. Institutions such as Wal-Mart, Home Depot, CVS, Kroger, Carrefour, Consorta, Novation, Univar, Ashland Distributors, and the Pentagon could play a significant role in implementing chemicals policies [5].

Moving toward 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 of through system losses (dissipation) and through end-of-life processing and release to the environment. 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, mapping the life cycle of chemicals, and engaging in dialogues with multiple parties along chemical and product supply chains, we can lay the foundation for a new, more comprehensive approach to chemicals policy.

SIX FEATURES OF A COMPREHENSIVE CHEMICALS POLICY

What can be meant by a comprehensive approach to chemicals policies? A simple definition of a comprehensive chemicals policy would be an inclusive, integrated, and prevention-oriented policy designed to achieve the use of nonhazardous and sustainable substances in the design, manufacture, and application of products or services.

The goals of a comprehensive chemicals policy follow from the United Nations commitment to the sound management of chemicals put forth in the Rio Declaration of 1992 and reiterated at the 2002 World Summit on Sustainable Development, assuring "by 2020, that chemicals are used and produced in ways that lead to the minimization of significant adverse effects on human health and the environment . . . [such that] . . . threats posed by toxic chemicals are eliminated in one generation" [6].

Comprehensive chemicals policies may be government policies or corporate policies. The newly adopted REACH (Registration, Evaluation, and Authorization of Chemicals) regulation in the European Union is an impressive example of a comprehensive chemicals policy [7]. Canada and several U.S. states are implementing forms of comprehensive chemicals policy. However, there are an increasing number of leading firms that are instituting across-the-board chemicals policies that cover all of the substances in their production processes. Examples include firms such as Nike, Herman Miller, Interface, HP, Timberland, Volvo, Philips, and S. C. Johnson [8].

While there are variations among these emerging examples of comprehensive chemicals policy, there are six primary features 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.
2. *Comprehensive chemicals policies prioritize chemicals into tiers.* These tiers range from substances that are undesirable and should be avoided to those that are preferred.
3. *Comprehensive chemicals policies are hazard- rather than exposure-based*. Exposure considerations can be useful in screening chemicals or setting priorities, but the intrinsic hazards of a chemical, not the potential for exposure, is the primary consideration in determining the safety of a chemical.
4. *Comprehensive chemicals policies create and open access to information.* These policies promote the generation and disclosure of critical information on chemicals ranging from production volumes and uses to human and environmental health effects.
5. *Comprehensive chemicals policies transition chemical use from higher-hazard to lower-hazard substances.* These policies drive and guide the phase-out of the most dangerous chemicals and the substitution of safer alternatives.
6. *Comprehensive chemicals policies promote research and innovation.* These initiatives promote the development of safer and more environmentally compatible chemicals.

In the sections that follow, each of these features is described in more detail.

A Comprehensive and Inclusive Approach

Over the years, the assumption that the chemicals problem involved only a modest number of chemicals and these could be regulated one by one did not hold. As human and ecological toxicology data has become available, it has become evident that many chemicals, indeed most chemicals, present some hazardous properties, ranging from acute hazards to chronic human health hazards, eco-toxicity, and adverse effects on the atmosphere. The United Nations' Globally Harmonized System for the Classification and Labeling of Hazardous Substances (GHS) identifies 26 categories of physical, human, and environmental hazards. Add to this the new nanoscale chemicals that remain largely uncharacterized, and the number of potentially hazardous chemicals is substantial [9].

A comprehensive approach to chemicals policy needs to address chemicals in a holistic and systemic manner. Such an approach views an individual chemical within the context of the chemicals market and seeks to understand its production and function in a way that identifies the possible alternatives that could be substituted for it. A holistic approach to all chemicals sets those chemicals that are unacceptably dangerous in a broader perspective that recognizes that there are also many chemicals that are safer and perform multiple functions well. By shifting from a focus on chemicals one at a time to a focus on branches of chemical production and groups of chemicals that function similarly, more strategic regulations and programs that work compatibly with ongoing market trends could be developed. The chemical market becomes a central unit of analysis and a focus for change.

The European Union has taken a big step forward with the enactment of the REACH regulation. This major overhaul of European chemicals policy requires the registration of all chemicals on the commercial market. The regulation does away with the conventional distinction between existing chemicals and those just coming onto the market and creates a level playing field, such that all chemical manufacturers of all chemicals (above a one-ton threshold) must present chemical dossiers that offer a minimum base set of chemical information [7].

A Tiered Approach to Prioritization

Unlike a half-century ago, there is now 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 new computational toxicology models assist in estimating the likely hazards of chemicals that exhibit certain common chemical structures when scientific studies are absent. An important function for government is the development and maintenance of a chemical classification system where all chemicals can be categorized as to their hazardous properties. The GHS offers an internationally recognized framework for implementing such a classification. This is not unreasonable. Working together, Health Canada and Environment Canada have completed a monumental effort to screen most all of the chemicals manufactured and used in Canada and have classified some 4,000 substances as high-hazard. With this as a foundation, the Canadian authorities are now setting priorities for addressing the chemicals of highest concern [10].

A holistic approach allows chemicals to be arrayed across a continuum ranging from the least to the most concerning. By creating tiers within the continuum and establishing a set of benchmark criteria for differentiating chemicals by their inherent properties, well characterized chemicals could be slotted into these tiers and grouped by level of concern into a landscape of chemical categories. Substances without sufficient information could be set aside in a category of "unknown concern." An illustrative typology presented in Figure 1 sets up five categories into which chemicals could be classified, such that priorities could be set and recommended strategies pursued.

While the government could formulate the framework, decision criteria, and rules for establishing a comprehensive categorization of chemical substances,

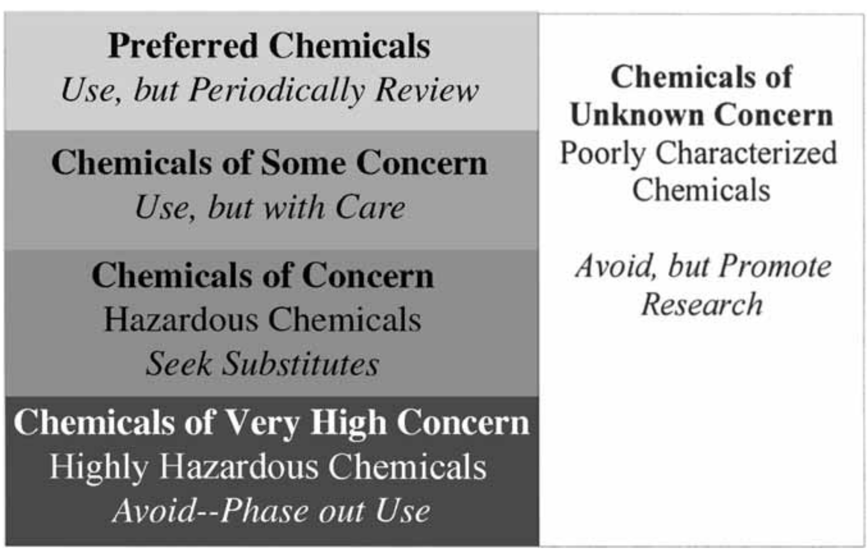

Figure 1. Comprehensive classification of chemicals.

it would be up to chemical producers and suppliers to categorize their chemicals and present evidence to support their characterizations. Such a classification would clarify what is known and not known about chemicals in use and lay out a framework for setting priorities for government attention. It would further identify where science and research should be targeted, either to characterize understudied chemicals or to develop safer alternatives. This tiered landscape would be valuable to chemical users in assisting them in converting from more to less concerning chemicals and to chemists designing safer chemicals or chemical production systems.

A Hazard-Based Approach

Since the 1980s the response to chemicals under TSCA and other chemical control laws has been informed by risk assessment and directed by risk management protocols. While, at the time, this created a better documented and more orderly approach, administrative commitments and judicial findings have locked chemical policy into this risk-based approach. A risk-based approach assumes, as given, that hazardous chemicals must be used and then directs government and business efforts to analyzing and managing those risks. Years of experience demonstrate that a risk-based approach often delays rather than promotes regulation, and diverts attention from more fundamental approaches to addressing chemical safety. The iconic tool for this is risk assessment; however, a risk-based approach is more than risk assessment. A risk-based approach often leads to risk management responses focused on managing and controlling the human and environmental exposure to hazardous chemicals. Expensive, and too often inadequate, pollution control technologies and personal protection equipment are often the result of a risk-based approach [11].

A risk-based approach has become fundamental to the way in which government regulates, business operates, and science is conducted. However, it is not the only way of understanding the chemicals problem or finding effective responses to it. Other approaches are available that can more directly address the threats of dangerous chemicals. Instead of conducting extensive chemical tests to determine what level of chemical exposure is acceptably safe, science could be directed towards developing inherently safer chemicals that could progressively replace chemicals of concern. This is the essence of a hazard-based approach. The objective is safer chemicals, not safer exposures.

Under a hazard-based approach, the focus is on the inherent hazards of a chemical. Inherent safety is a term often used in the chemical industry to describe "primary prevention" or the elimination of a hazard. This differs from "secondary prevention," which includes processes that seek to reduce the risk of a hazard, often by the use of technological barriers or managerial controls. Primary prevention involves preventing harms by using safer technologies, reducing emissions and wastes and eliminating workplace hazards. Here the focus is on substituting safer chemicals for chemicals of concern and converting to cleaner and safer technologies, thereby reducing the threats of chemicals before exposure occurs. It is a fundamental tenet of prevention that reducing or eliminating a hazard is more effective, and often less costly overall, than constructing safeguards against it.

The principle of prevention seeks to reduce or eliminate the inherent hazards of a chemical either at the selection stage, prior to use and prior to exposure, or at the design stage, prior to manufacture, use, and exposure. In Europe this is called the "prevention principle" and it is often aligned with the precautionary principle. Like the precautionary principle, the prevention principle is anticipatory and proactive, reducing the probability of harm well before the harm can be experienced.

Washington, Maine, California, and Minnesota have all recently passed legislation authorizing special restrictions on chemicals of high concern [12]. While exposure considerations do still play a role in setting priorities among chemicals under a hazard-based approach, government responses are based on the intrinsic hazards of chemicals.

Generating and Disclosing Information

A comprehensive chemicals policy requires chemical producers and users to present sufficient information on the effects of chemicals, support the science that underlies that research, and ensure that the information is made available to all those who need it. Generally, there are three areas for information development. These are:

Information on the inherent characteristics of chemicals. In order to properly classify, prioritize, and regulate chemicals, a minimum set of chemical health and environmental effects information is needed for every chemical on the market. Such a base set of data should include the physical-chemical characteristics, the toxicological properties, the biological behavior, and the fate and transport characteristics in the environment

Information on the production, use, and life cycle of chemicals. In order to understand and account for how chemicals appear, change, and disperse in the economy, information is needed on the manufacture, importation, distribution, use, and disposal of chemicals across their life cycles.

Information on release and exposure of chemicals. In order to understand threats from chemicals and to prioritize attention and interventions, information is needed on the releases of chemicals as wastes and emissions, actual and potential human exposures to chemicals, and the presence of chemicals in environmental media, humans, and other organisms.

This information may be developed by 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. 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. Past experience demonstrates that market incentives will not guarantee that adequate chemical information is generated or made available for all chemicals. The European Union's principle under REACH of "no data, no market" creates an effective incentive for information development and presentation.

A competitive business environment requires that certain chemical information submitted to the government be protected. But the massive overuse of confidential business information protections under the current chemicals control laws have deprived the market and the public of information critical to making sound decisions in selecting chemicals or buying products. The health and environmental effects of a chemical should never be classified as a trade secret, and government standards for protecting confidential business information should require sufficient justification and set time limits that require periodic re-applications.

Transitioning to Safer Alternatives

Those who drafted the chemicals control laws of the 1970s relied heavily on the regulatory powers of government to reduce the threats of hazardous chemicals. This was primarily a one-tool strategy. The regulatory approach made sense if the chemical problem was defined as eliminating a modest number of chemicals of high concern. However, if the problem is framed as a broader systems problem, then the task is to transition chemical manufacture and use from highly hazardous chemicals toward more preferred and safer chemicals. We need to think less about restriction and more about conversion.

This requires a campaign of many initiatives—working together to achieve a common goal. Government regulation must be one of those instruments, but so should new government investments and government assistance programs, as well as new tax and capital depreciation policies, new market incentives, new consumer services, and new partnerships among industries and among industries, universities, and governments.

Conventional government regulations are useful in restricting things, and with "chemicals of very high concern," use restrictions and production bans make sense. This should involve the persistent, bioaccumulative, and toxic chemicals as well as the carcinogens, mutagens, and reproductive toxins. Experience with licensing as required for pesticides that must be registered demonstrates an effective and orderly approach to the regulation of chemicals deemed hazardous, but not of such very high concern. The burden of proof is on chemical manufacturers and users to demonstrate that a substance meets a baseline of safety and, if it does not, proving that there are no other available alternatives.

However, government regulations cannot promote safer chemical substitution or chemical innovation without additional services. The Massachusetts Toxics Use Reduction Program uses government regulations to require that chemical manufacturers and users prepare plans on possible substitutions, but relies on the dedicated attention of government technical assistant agents, university trainers and scientists, and various forms of demonstration subsidies and public recognition programs to support conversions to safer chemicals or technologies [13].

The environmental advocacy community has been working over the past decade within several economic 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 safe 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, an international coalition of hospitals, health care services, and advocates. 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 [14].

A comprehensive chemicals policy could adopt similar efforts and be organized around the conversion of economic sectors. Programs would be set up in targeted economic sectors with the objective of moving the material flows in that sector to safer and more sustainable chemistries. Efforts to phase out hazardous chemicals and substitute safer alternatives would 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 may be more readily diffused where early adopters within a sector model behavior for later adopters. Working within sectors can be coordinated with other programs to meet multiple objectives. Efforts to convert a sector on chemicals can reinforce efforts to convert that same sector on carbon emissions, water consumption, or workplace rights and reduce concerns that these are competitive objectives.

Promoting Innovation and Green Chemistry

A comprehensive chemicals policy should focus as much on developing higher-tier, preferred chemicals as on phasing out lower-tier chemicals of very high concern. 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 should be developed and synthesized through green chemistry principles [15].

Today, there simply are not enough alternative substances 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 on a sufficient scale cannot 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 is very limited.

The government should establish a national green chemistry and engineering initiative with the same commitment and resources that once launched the Apollo Project. Such an initiative could be modeled on the National Nanotech Initiative that today offers over $2 billion annually in research support through 10 cooperating federal agencies. This new initiative should provide:

A federal extramural research program. Just last year, Congress established a Green Chemistry Basic Research Program at the National Science Foundation; however, no appropriations were provided [16]. A Green Chemistry Research and Development bill that would provide funding for green chemistry research has been languishing in Congress for five years [17]. Both these initiatives need attention.

Regional green chemistry and engineering centers. Funding for some four to six 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.

Aid 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 curricula and supporting students engaged in undergraduate and graduate green chemistry and engineering programs.

A NEW NATIONAL CHEMICALS AGENCY

A comprehensive chemicals policy requires a coordinated and integrated approach to chemical information generation, regulation, and promotion, and this will require reconsideration of current government structures. With some 15 federal agencies and many more state agencies responsible for chemicals management, 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 [18] and the new European Chemicals Agency in Helsinki [19] offer interesting models for no-regulatory government divisions that oversee chemical information (see Figure 2).

Such a new federal agency could be a nonregulatory division that serves as a focus for collecting and making accessible chemical information generated by chemical manufacturers and users and developing and managing the national categorization of chemical substances. In addition, the chemicals agency could serve to coordinate funding for the green chemistry and engineering initiative and help to promote new chemistry and engineering curricula.

A new nonregulatory chemicals agency would not replace the current regulatory agencies responsible for chemical testing, permitting, standard-setting, and compliance with chemical laws. Rather, a new central agency would serve as a

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 product's register, 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.

The European Union's Chemicals Agency ECHA

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

Figure 2. Models of governmental chemicals agencies.

focal point and resource for chemical information and coordination among the many regulatory agencies.

COMPREHENSIVE CHEMICALS POLICY FOR THE FUTURE

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

TSCA and the other chemicals control laws need to be redrafted and amended. However, in addition to such law reform, the nation needs a broad and comprehensive overhaul of its chemicals management strategy based on a broader understanding of the chemicals problem and a different perspective on the solutions. 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 the European Union's chemicals policy [20].

We could set about to work for a truly comprehensive chemicals strategy. Such a strategy, built from a systems perspective, would phase out the most hazardous chemicals and progressively transition away from the remaining chemicals of concern by substituting safer alternative chemicals and technologies. Well-resourced science and scientists must play a critical role here in generating chemical information and developing safer alternatives. This may appear like an overly ambitious mission. However, if we cannot envision it, if we cannot debate it and develop it, we will never achieve it. Now is a good time to engage that process.

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