Center for American Progress

Critical Infrastructure Security Series

New Strategies to Protect America: Securing our Nation's Chemical Facilities

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Progressive Ideas for a Strong, Just, and Free America

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Executive Summary

More than three years after the attacks of 9/11, our nation's chemical manufacturing and transport facilities remain extremely vulnerable to terrorism. The Bush administration's reliance on voluntary actions by the chemical industry has failed to produce sufficient change at the nation's 15,000 facilities that use or produce deadly chemicals. Yet there are readily available hazard-reduction techniques including replacing the most dangerous chemicals with less toxic substances, reducing the amount of chemicals we store, and hardening facilities to both deter and protect against potential attacks.

Voluntary approaches have failed to accomplish what our national security requires, leaving us with no choice: the administration must put aside its ideological resistance to federal action, overcome private sector inertia, force a change in the status quo, and put into place new safety measures. Tax incentives, up-front low interest loans or homeland security grants can be used to speed the process and relieve some financial burden on the industry. Action cannot wait.

In this, the first in a series of papers on protecting our critical infrastructure, the Center for American Progress sets out a 12-month action plan to reduce the risks posed by the nation's chemical facilities. We recommend using existing government and industry data to create a priority list of the most vulnerable facilities that produce or use the most dangerous toxic chemicals, making them prospective terrorist targets. We then call for immediate leadership by the Environmental Protection Agency to write new, effective guidelines on reducing hazards. This would be followed by audits of these priority facilities and the creation of plans to use state-of-the-art techniques to increase safety. Facility operators who fail to aggressively implement these plans would be subject to strong enforcement action and significant penalties. Finally, we recommend that the government fund a new program devoted to the longer term task of developing safer alternatives to today's deadly chemicals. Taken together, these steps form a specific, concrete and actionable plan to protect our communities and make our country more secure.

Background

The attacks of 9/11 tragically revealed our nation's vulnerability to terrorism. In response, Congress and the Bush administration committed to secure "critical infrastructure and key assets" under the Patriot Act.[1] The 2002 National Strategy for Homeland Security established critical infrastructure protection as a "critical mission area."[2] But today, despite this obligation, there has been insufficient progress in protecting the public from potential attacks on the nation's most dangerous chemical facilities, which remain vulnerable high-impact targets for terrorists intent on damaging our nation.[3]

The U.S. Environmental Protection Agency (EPA) estimates that more than 100 chemical facilities in 24 states threaten *more than a million people each*,[4] and the industry's own assessments do not disagree.[5] These are only the biggest targets among the nation's more than 15,000 chemical plants. "No one needed to convince us that we could be – and indeed would be – a target at some future date," the president of the American Chemistry Council (a Washington-based industry association) said a few weeks after 9/11. "If you are looking for a big bang, obviously you don't have to go far in your imagination to think about what the possibilities are."[6] Recent accidents underscore the severity of the risk. For example, in January, a train carrying chlorine gas derailed near Graniteville, South Carolina. The resulting release of the gas killed nine, but might have caused more than 100,000 deaths in a major urban area.

Several dozen acutely dangerous chemicals are used in significant quantities in and around large population centers. Chlorine gas is commonly used at wastewater treatment facilities, putting 19 million Americans at risk.[7] The nerve gas phosgene is a key ingredient for manufacturing plastics. Concentrated ammonia – the major ingredient used in the Oklahoma City bombing – is used by scores of manufacturers to make fertilizer. And cyanide compounds are used to manufacture nylon.

Despite this danger, security at the nation's chemical plants has historically been treated as a secondary concern, the province of a small cadre of environmental and public safety professionals. As part of the 1990 amendments to the Clean Air Act, Congress directed each chemical facility to develop a "Risk Management Plan" (RMP) (see box). These plans include, among other things, five-year accident histories, measures to prevent an accidental release, response plans to mitigate damage should one occur, and assessments of potential dangers to surrounding communities, including worst-case scenarios. Yet up until now, companies have not been required to assess and consider inherently safer methods of operation. The private sector has yet to understand or embrace the increased security requirements that now exist beyond traditional safety and environmental concerns. We have lost valuable time.

Immediately after 9/11, there was an attempt to jump-start an aggressive program to reduce the attractiveness of chemical plants to terrorists. Congress held hearings and, just six weeks after the attacks, Sen. Jon Corzine (D-NJ) introduced the Chemical Security Act of 2001. The bill, which quickly received substantial bipartisan support, focused on sites across the country where hazardous chemicals were produced or stored and called for the chemical industry to switch to less dangerous processes "to the extent practicable."

However, industry strongly resisted government efforts to decrease the nation's vulnerability to terrorist attacks at its facilities. Thirty trade associations, including the American Chemistry Council, American Petroleum Institute, American Farm Bureau, Edison Electric Institute, National Association of Manufacturers, and U.S. Chamber of Commerce, opposed the Corzine bill. The bill died in Congress without even a vote.

For appearances sake, the administration worked with Sen. James Inhofe (R-OK) to develop a far weaker bill. It provided no government authority to enforce safety requirements or require emergency action by companies. Incredibly, companies were not even obligated to submit self-assessment plans for government review and approval. As Rena Steinzor of the Center for Progressive Regulation put it, the Inhofe bill "was like giving your class an open-book take home exam – and telling them you're not going to collect it."

Excessive Secrecy Threatens Accountability

More than two years before the 9/11 terrorist attacks, Congress decided to restrict public access to worst-case scenario assessments contained in the Risk Management Plans (RMP) of chemical companies. These assessments estimate the number of people in the surrounding area who would be killed or injured from a catastrophic chemical release.

As a result of Congress's action, the public can only obtain this information in 50 "reading rooms" around the country. EPA and other federal agencies are prohibited from disseminating it through the Internet (though parties who obtain the information from the reading rooms can disseminate it as they see fit).

Congress took this action after the chemical industry – a longtime opponent of such disclosure – convinced the FBI that worst-case scenario data created an increased risk of terrorism. At the time, the FBI determined there was no increased risk associated with the rest of the information contained in RMPs, including accident histories, prevention measures, and disaster plans. Nonetheless, despite the FBI assessment, EPA immediately yanked this information from its web site following 9/11. To date, all RMP information remains off-line, without any detailed explanation.

Security is important, and goes hand-in-hand with accountability. In the past, community groups and environmental organizations, as well as the media and everyday citizens, have used such information to hold corporations and government accountable. This public pressure has achieved significant safety improvements. For example, since facilities began publicly reporting toxic releases in 1988, releases have declined by nearly 50 percent.[21] This is no less true when it comes to security. Sufficient information should be available for the public to judge that clear security standards are being established and action taken. Risk Management Plans continue to have an important role to play and need to more accessible to the public.

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Chemical Transport Part of the Equation

When industrial plants switch to non-explosive and non-lethal chemical alternatives, they will no longer need to transport these hazardous materials. Thus, improving chemical plant security can also improve transportation security.

As it stands, railroad tank cars carrying deadly chemicals make for inviting targets. They are not guarded like chemical plants; indeed, many tank cars are covered by graffiti, testifying to their vulnerability. Making matters worse, more than half of the nation's 60,000 tank cars that carry hazardous materials were built before 1989 and are not up to current industry standards, making them less resistant to rupture, according to the National Transportation Safety Board.[22]

Unfortunately, the Bush Administration has failed to show leadership in the transportation area, just as it has with chemical plants. "The federal government has the authority to regulate the security of chemicals as they are being transported on roads, railways and waterways," Richard A. Falkenrath, President Bush's former deputy homeland security adviser, pointed out in a recent *Washington Post* op-ed. "With only one minor exception, the administration has not exercised this authority in any substantial way since Sept. 11. There has been no meaningful improvement in the security of these chemicals moving through our population centers."[23]

A number of measures are needed to address the transport of hazardous chemicals. This includes improved physical security and surveillance, real-time tracking of trucks and rail cars hauling dangerous cargoes, routing hazardous material away from target cities, and halting storage of hazardous chemicals in rail cars outside a plant's perimeter. The Center for American Progress intends to offer more detailed recommendations on chemical transport in a forthcoming report.

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Even the Inhofe bill never went to the Senate floor for debate and a vote.

While this was dying in Congress, EPA initially stepped up to the plate, asserting that it could address the problem using its existing authority under the Clean Air Act. The Clean Air Act authorizes EPA to issue regulations to prevent any "unanticipated emission of a regulated substance or other extremely hazardous substance into the air" and imposes a "general duty" of precaution on sources, directing them to "design and maintain a safe facility" in order to prevent dangerous releases.[8] Because few actions are as unanticipated as terrorism and because operating a safe facility includes reducing its vulnerability to attack, this language gives EPA ample authority to create strong, mandatory security standards.

Unfortunately, EPA had little political support within the administration to move forward, and the Bush White House ultimately transferred lead responsibility for chemical plant safety to the Department of Homeland Security (DHS), which lacks clear statutory authority to require industry action. In her new book, then-EPA Administrator Christine Todd Whitman explains that she was frustrated by "the lack of support we were receiving in meeting our responsibility."[9]

At the time of the transfer, Whitman and then-DHS Secretary Tom Ridge issued a joint statement explaining that voluntary measures by the chemical industry were not enough. Ridge also testified before Congress that post-9/11 security deficiencies had been validated at dozens of chemical facilities across the country.[10] Nonetheless, the Bush administration failed to show the leadership necessary to overcome Congressional opposition to passing robust and mandatory protections.

On the industry side, in June 2002, the American Chemistry Council (ACC) issued new standards that called on its members to add security assessments, timelines and independent validation of security improvements. However, this third-party certification is limited to goals set by the companies themselves.[11] Indeed, external reviewers, who are selected by the company being evaluated, do not consider safer chemicals and process changes that could eliminate the need for add-on physical security (such as fences, alarms, and lights). Nor do they need to have expertise in design engineering for reducing hazardous chemicals. This approach, as documented by the General Accounting Office, does not go far enough to meet today's security requirements.[12]

Thus far, industry steps have focused on enhancing physical security around their plants. This has meant higher fences and increased surveillance, and in some cases, updated warning and evacuation plans. These techniques are not focused on reducing the chances of a deadly attack but rather on detecting and frustrating attacks about to occur and protecting residents after an attack.

The lack of risk reduction has left the public at substantial risk. Journalist Carl Prine of the *Pittsburgh Post Gazette* attempted to enter 30 facilities and found "almost non-existent security in a lot of places," including one Chicago facility where he sat on top of a chemical tank and waved at security personnel. "I began to wonder," Prine told *60 Minutes*, "what would it take for me to get arrested at one of these plants? Would I have to come in carrying an AK-47? What would it take for someone to say, 'Why is this guy walking around taking pictures of our tanks?'"

It is not hard to identify the primary reason behind the anemic effort to reduce the hazards posed by deadly chemicals: the Bush administration's decision to rely only on voluntary industry efforts. As in other major economic sectors, the White House has essentially allowed the chemical industry to police itself – even in the face of widespread consensus by its own experts that these plants are easy, deadly targets. Security has been trumped by a reflexive ideology that rejects government regulation out of hand. Recently, the Bush administration listed 15 potential disaster scenarios to focus homeland security preparedness. One of these scenarios involved the deliberate explosion of a chlorine tank at an industrial facility. Yet the administration has never required steps that would make such a catastrophe less likely to occur. It also joined with the railroad and chemical industries to contest a new ordinance passed by the City of Washington, D.C. that restricts the routing of rail cars carrying hazardous material through the city to other destinations (see box page 3). Warren Rudman, co-chair of the U.S. Commission on National Security, pointed out the problem with following industry's line: "With all due respect, and I'm a great admirer of private business, private business does not necessarily always have the public interest uppermost in their minds."[13]

EXISTING SOLUTIONS: INHERENT HAZARD REDUCTION

Ironically, chemical manufacturers and users in the United States already have the techniques and tools they need to better protect public safety and reduce the terrorism risk to their facilities. Physical security upgrades should be encouraged and supported, but alone are inadequate. The chemical industry must rapidly reduce reliance on potentially lethal chemicals that are most likely to attract terrorist interest in the first place.

The best answer lies in a process known as "inherent hazard reduction," which sets forth a hierarchy of effective, readily available techniques. By eliminating or greatly minimizing the quantities of acutely hazardous chemicals stored in any one plant or site, this approach has the potential to significantly reduce the number of vulnerable targets and the risks associated with those targets. Up to this point, however, the chemical industry has overlooked or ignored these techniques. Inherent hazard reduction includes four primary elements: materials substitution, just-in-time manufacturing, inventory reduction, and hardened storage.

Materials Substitution

The goal of materials substitution is clear: replace acutely toxic substances with less dangerous alternatives. This technique sits at the top of the hazard reduction hierarchy and should be the option of choice wherever possible.

Take the example of water treatment and disinfection, where there are already non-toxic, non-explosive alternatives for widely used and deadly toxic compounds. The current system combines chlorine gas and sulfur dioxide gas. Each of these chemicals is highly toxic; chlorine gas poses an acute and deadly risk to populations wherever it is in heavy use. Using the substitution approach, chlorine is replaced with sodium hypochlorite (industrial bleach), which won't explode, or ultraviolet light, which avoids chemicals altogether. Sulfur dioxide is readily replaced with a variety of alternative chemical-reducing agents, including thiosulfate.

Elimination of these two highly toxic chemicals is an extremely practical option that is already gaining acceptance. Many water/wastewater facilities have already undertaken this option. In a December 2003 report, Environmental Defense examined each wastewater facility that in 1999 reported that a chemical accident at its plant would endanger 100,000 or more people.[14] Of the 62 such plants, a dozen had since switched from chlorine to sodium hypochlorite or ultraviolet light. This includes plants in California, Florida, Georgia, Louisiana, Michigan, Ohio, Pennsylvania, Utah, Washington, and Washington, D.C. (see box).

Substitution is more difficult, but not impossible, where a chemical is used as a critical feedstock for industrial manufacturing. For example, polycarbonate plastics, which are currently manufactured by some companies using the dangerous nerve gas phosgene, can be made using a much more benign transesterification process. Polyurethane foams, which are currently manufactured by some companies using toluene isocyanate (a cyanide derivative) can also be manufactured with alternative chemical compounds.

Material substitution also has a clear side benefit for transportation, particularly rail and truck security. Because of material substitution, fewer rail cars carrying hazardous materials are today moving through on lines that pass literally within yards of critical areas, including government offices like the U.S. Capitol.

Of course, companies that use dangerous chemicals in a manufacturing or business process are most likely to adapt less toxic alternatives if they are relatively cost effective. Substitution benefits safety and security, which in turn reduces long-term risk. Less dangerous substances can be

What's Good for Washington, D.C…[24]

For years, the Blue Plains Wastewater Treatment Plant in Washington, D.C. stored hazardous chlorine gas in 90-ton rail cars. A rupture of just one of these rail cars would have put 1.7 million people at risk, and would cover the White House, Congress, and Bolling Air Force Base.

These risks had been known for almost two decades, prompting repeated complaints from the Department of Defense and the City of Washington – which commissioned a study in 1991 that recommended industrial bleach as a safer substitute for the more dangerous chlorine. Yet the Blue Plains facility refused to change, no government action was taken, and the danger persisted.

Then came 9/11. Suddenly, the threat of a terrorist attack on the plant, setting off a deadly release of chlorine, became very real. Indeed, the *Washington Post* reported that trade publications from the U.S. chemical industry were found in a hideout of Osama bin Laden.[25] In short order, the Blue Plains facility removed its 90-ton rail cars, and began to use sodium hypochlorite bleach, which does not have the potential to drift off-site, as a substitute for chlorine.

Initial construction costs associated with the switch were about $500,000; subsequent capital improvements were completed in 2003 at a cost of $15 million, adding about 25 cents to the average customer's monthly bill.[26] These costs have been substantially offset by a reduction in costs for security, maintenance (which have declined $300,000 annually), and hazardous substance rule compliance.

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cheaper to transport. Less risk reduces liability, which may also translate into lower commercial insurance premiums.

Substitution may not be immediately economically feasible for companies that manufacture acutely toxic chemicals as products. However, the government should develop financial incentives – including tax breaks, upfront low-interest loans or homeland security grants – for research and development of safer alternatives.

Just-in-Time Manufacturing

Just-in-time manufacturing aims to limit storage of acutely toxic substances by adopting manufacturing processes that reduce the need to store deadly chemicals. Where industry simply cannot substitute fewer acutely toxic substances, this process calls for synthesizing immediately before using the molecules of a chemical needed for a reaction, rather than synthesizing them earlier and storing them in reserve.

Just-in-time manufacturing is an eminently practical option in many situations and has been undertaken by many companies. For example, at many of its plants today, Dow Chemical produces phosgene using this process. DuPont adopted this technique for producing methyl isocyanate in the immediate wake of the Bhopal disaster in 1984.[15] With the advent of nanotechnology that enables more efficient use of chemicals, the potential for just-in-time manufacturing could increase exponentially,[16] adding further impetus for the chemical industry to abandon old school rules and adopt inherently safer and more secure practices.

Inventory Reduction and Separation

Where substitution and just-in-time manufacturing are not feasible, chemical plants should aim to decrease total storage inventories of acutely toxic substances, or should that prove impossible, take steps to separate inventory into smaller tanks and containment vessels. Both of these techniques will decrease the likely impact of a terrorist attack, while also offering terrorists less accessible targets.

Reduction in on-site storage and so-called “fractionation” involve marginal up-front costs, but risks can be substantially diminished. For example, in the late 1990s, Bayer redesigned a cooling system at one of its plants to eliminate about 30 percent of the ammonia inventory;[17] around the same time, Kodak stopped using large one-ton containers to store chlorine gas and began using 150-pound cylinders instead, eliminating the potential off-site impact from a worst-case release.[18] Industry needs to adapt its facilities and operations based on the real possibility that intruders will deliberately try to kill or injure as many people as possible, destroy as much property as possible, and instill panic and economic disruption within major communities.

Hardened Storage

In cases where all of the first three techniques are determined to be infeasible, the best short-term solution is to harden or hide storage vessels of acutely toxic chemicals to decrease their vulnerability as targets. One way to do this is to store chemicals underground. A number of large flammable gas storage facilities are underground caverns, including a Marathon facility in Woodhaven, Michigan, and an AmeriGas facility in Waddell, Arizona. Tanks and other storage facilities need to be less visible, less accessible, and less vulnerable to deliberate attacks or sabotage. The federal government has the power to raise minimum facility standards.

A Strategic Action Plan

New Secretary of Homeland Security Michael Chertoff spoke recently about a “hierarchy of risks” and the need to “put our resources to work in a way that most closely approximates the most serious risks with the worst consequences and the greatest vulnerabilities.”[19] The administration’s hands-off approach to chemical facilities is at odds with this stated objective.

The issue is not whether voluntary approaches are inherently good and government regulation is inherently bad. The only question that matters is whether our critical infrastructure is adequately protected. When it comes to chemical facilities, the answer is no. Voluntary approaches have not worked. It’s time to change our strategy.

We strongly urge the administration to set aside its general hostility toward regulation of industry and properly address the catastrophic potential that an attack on a chemical plant poses to public safety. The required federal authority already exists and none of the recommendations that follow requires the enactment of new legislation. Genuine progress in assessing and addressing the risks posed by chemical plants to the American public is achievable within 12 months. A fast-track action plan should include the following steps.

Set Priorities

Neither the private sector nor the federal government can solve overnight the problem posed by the more than 15,000 chemical facilities around the country. Our goal should be to stay focused on the facilities that pose the greatest threat, and to set priorities based on which ones use the deadliest chemicals in significant quantities—those that cause immediate, catastrophic effects such as creation of windborne toxic plumes that can move without warning into nearby communities. Many, if not most, of the chemicals used in daily commerce do *not* meet these criteria.

Fortunately, information is readily available to identify and prioritize the most dangerous chemicals that make priority facilities vulnerable to terrorism. EPA has been in the business of collecting information about chemical plants for more than 30 years; various technical guidance documents and computer programs are already available to interpret this information and set priorities. Furthermore, for many years, industry has been required to provide the government with chemical storage data for every facility.[20] There are no legal or regulatory obstacles to quickly identifying the highest priority industrial facilities. We can develop a priority list through four simple steps:

1. *Identify acutely toxic chemicals.* Acute toxicity values for a chemical indicate the concentration that could be fatal. Several government agencies, including EPA, the Occupational Safety and Health Administration and the Department of Transportation, provide toxicity values of a long list of chemicals, often tiered by the severity of their toxic effect. Toxicity values from the National Advisory Committee for Acute Exposure Guideline Levels for Hazardous Substances and the American Industrial Hygiene Institute's Emergency Response Planning Guidelines are particularly comprehensive and well-suited for the task of assessing the level of toxicity of facilities, though several other compilations could also be used.

2. *Focus on chemicals that will create a toxic plume in the event of an attack.* The volatility of the selected acutely toxic chemicals must be evaluated in order to properly identify those that would disperse off site if a storage tank were hit in close proximity to a major population center. For this analysis, we recommend EPA's Computer Aided Management of Emergency Operations (CAMEO) and Risk Management Planning Program (RMPComp), two computer programs which have been used for many years by local emergency planning agencies and industry for assessing potential off-site consequences of chemical accidents. The volatility values assigned in these programs take into account the vapor pressure of a chemical and its molecular weight to predict the extent to which a chemical will create a vapor plume.

Table 1 provides a list of 20 chemicals in commerce that rise to the top of the list using an assessment methodology that combines toxicity and volatility. Table 2 summarizes the adverse health effects caused by exposure to these chemicals and their predominant use in industry.

3. *Research quantities of toxic material stored at nation's plants.* We should identify the facilities that store significant quantities of the top priority acutely toxic chemicals. The chemical storage data that industry is required to routinely report to the government provides the basic information necessary for this task. Because peculiarities of the current reporting requirements can cause "double-counting" errors – making plants appear more dangerous than they actually are – we recommend that the government check against these errors by contacting key facilities that rise to the top of the priority list. Longer term, the existing reporting requirements should be modified to eliminate the possibilities of double-counting.

4. *Rank danger of plants by creating inherent hazard score.* The next step is to create a simple quantitative equation to analyze these factors and develop an inherent hazard score of the chemical facilities that pose the greatest risks to the nation. We recommend the equation presented below, which gives a straightforward quantification based on the key characteristics of concerns discussed above, although other similar quantifications could also be developed.

(Toxic Plume Factor/Toxicity) X Storage Quantity = Facility Score

The government could also include additional risk factors, including population density, into its ranking of priority sites. Because necessary information is readily accessible and the technical issues key to assessment are trivial, we conservatively estimate that the government should be able to create its list of target chemicals of concern and the most important facilities that store them in less than 30 days.

Strengthen Existing Government Authorities

On a parallel track, the government should set up an expert task force, through the National Academy of Sciences or a similar organization, to write guidelines for aggressive and effective hazard-reduction measures. EPA should adopt these recommendations as an update to its guidance under section 112(r) of the Clean Air Act.

EPA should issue emergency regulations under section 112(r) of the Clean Air Act and section 553(b) of the Administrative Procedure Act requiring priority facilities to arrange for immediate and rigorous independent audits of their management of priority chemicals. These audits would help determine every possible option for adopting inherent hazard reduction techniques. We recommend that these audits culminate in the filing of a sworn statement that every feasible option for inherent hazard reduction has been identified, and that the recommended hazard reduction program be implemented as quickly as possible, with a schedule and milestones agreed to by the audit team. In every instance where inherently safer technologies cannot be adopted, facilities should implement site security that includes 24/7 monitoring of all facility perimeters to prevent potential attacks, criminal screening of employees, and use of the best available technologies to otherwise secure the facility.

False statements, or failure to submit a sworn statement, should be enforceable by both civil and criminal penalties as violations of the general duty clause in section 112(r) of the Clean Air Act and/or 18 U.S.C. 1001.

A 12-Month Plan of Action

Within 30 days, the EPA should develop a list of plants that pose the greatest risk to citizens based on the criteria identified above. This plan is fully consistent with both the nature of the threat from global terrorist networks, such as al Qaeda, and the Department of Homeland Security's repeated pledge to devote its energies and resources where the risk is most significant.

Within 60 days, joint DHS/EPA teams trained in both *inherent hazard reduction* and site security should inspect the 25 highest priority facilities in the country, moving on to the next 25 within the following 60 days. Inspections should specify areas that make priority facilities vulnerable to terrorist attack and recommend steps that could and should be taken to employ inherent hazard reduction techniques and improve site security.

These findings and recommendations should be transmitted to each facility's owner and operator in the context of a letter defining their "general duty" under section 112(r) of the Clean Air Act. Industry should be required to respond within 90 days. The government should take appropriate enforcement action against those who do not agree to implement the recommendations.

Assuming that the rate of inspections will accelerate as more experience is gained, joint EPA/DHS teams should complete evaluations of the top 500 priority facilities within a year. During that same timeframe, the government should establish a program at the National Institute for Standards and Technology to conduct research on substitutes for certain industrial applications of acutely toxic chemicals. In conjunction with this effort, EPA should conduct an inventory of hazard-reduction efforts – both in the United States and in other countries – and identify best practices. This information should be used to educate facilities and promote quick adoption of safer manufacturing processes.

Conclusion

Homeland security is an integral dimension of national security. If we are to make our citizens, communities, and economy less vulnerable to terrorist attacks, the status quo is unacceptable. In the eyes of global terrorists, chemical facilities are "potential weapons of mass destruction." We have to be just as serious and determined to make them more secure as we are confronting the very real dangers posed by weapons of mass destruction abroad. Since 9/11, the Bush administration has engaged in preventive war abroad, but has not yet taken preemptive steps to address imminent threats in our midst.

Where the threat is real and the risk significant, the security of the United States – its people, its communities and its economy – should trump special interests. Voluntary approaches have been tried by the Bush administration. The industry's response has been insufficient. The government has the authority and power to identify the most vulnerable sites and insist on action. The government must lead. Fortunately, there is a strategy that can be immediately implemented to make our country and our communities more secure.

ABOUT THE AUTHOR

Dr. Linda Greer is a Senior Scientist and Director of NRDC's public health program. She specializes in issues related to toxic chemicals and hazardous waste, currently focusing on mercury pollution and the risk assessment methodologies for toxic chemicals. Linda is also the author of numerous technical and policy articles on environmental matters, and she has frequently testified before Congress. She received her doctorate in Environmental Toxicology from the University of Maryland and her master's degree in environmental sciences and engineering from the University of North Carolina's School of Public Health. Mr. Steve Anderson, an independent consultant now working for the New Jersey Department of Environmental Protection, contributed substantially to the original underlying analysis that led to this report.

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ENDNOTES

[1] USA PATRIOT ACT, Pub. L. No. 107-56 (2001), § 1016(e).
[2] Office of Homeland Security, National Strategy for Homeland Security, at 29 (July 2002), *available at* http://www.whitehouse.gov/homeland/book/nat_strat_hls.pdf.
[3] This paper focuses on chemical manufacturing facilities and the substances stored on their premises. The second in the Center's series on chemical infrastructure will explore in-depth the issue of transporting chemicals and other toxic substances across the country.
[4] Joby Warrick, *An Easier, but Less Deadly, Recipe for Terror*, Washington Post, December 31, 2004, at A1.
[5] EPA's assessments are based on industry-generated Risk Management Plans.
[6] Eric Pianin, *Toxic Chemicals' Security Worries Officials*, Washington Post, November 12, 2001, at A14.
[7] Environmental Defense, Eliminating Hometown Hazards: Cutting Chemical Risks at Wastewater Treatment Facilities, at 7 (December 2003), *available at* http://www.environmentaldefense.org/documents/3357_EliminatingHometownHazards.pdf.
[8] 42 U.S.C. 7412(r)
[9] Christine Todd Whitman, It's My Party Too, 163-165 (Penguin, 2005).
[10] Testimony before the Senate Committee on Environment and Public Works, July 10, 1002.
[11] Paul Orum, *Responsible Care Still Lacks Teeth*, Careline, Spring 2003.
[12] GAO, Voluntary Initiatives are Underway at Chemical facilities, but the Extent of Security Preparedness is Unknown, GAO 03-493, March 2003, *available at* http://www.gao.gov/new.items/d03439.pdf.
[13] Speaking on "Now with Bill Moyers" about Bush administration policies on possible terrorist attacks at chemical plants, March 21, 2003.
[14] Environmental Defense, Eliminating Hometown Hazards: Cutting Chemical Risks at Wastewater Treatment Facilities, at 6 (December 2003), *available at* http://www.environmentaldefense.org/documents/3357_EliminatingHometownHazards.pdf.
[15] On Dec. 3, 1984, a Union Carbide plant in Bhopal, India, released 40 tons of the toxic chemical methyl isocyanate into the surrounding community, killing 3,800 and sickened or injured more than 170,000, tens of thousands of which still suffer long-term effects.
[16] For a discussion of nanomanufacturing, *see* The Royal Society, Nanoscience and Nanotechnologies: Opportunities and Uncertainties, Chapter 4, July 29, 2004, *available at* http://www.nanotec.org.uk/finalReport.htm. As this report notes, some applications of nanotechnology may actually pose new health and environmental risks; such potential risks should be considered before nanotechnology is used in manufacturing.
[17] This example is drawn from a letter from Helge H. Wehmeier, president and chief executive officer of Bayer, to a coalition of environmental and public interest organizations (August 27, 1999).
[18] This example is drawn from a letter from David M. Kiser, director of health, safety and environment at the Kodak Park Site, to a representative at the National Environmental Trust (August 9, 1999).
[19] Testimony before the Senate Homeland Security and Governmental Affairs Committee, March 9, 2005.
[20] 42 U.S.C. 7412(r)
[21] *See* EPA, *The Toxics Release Inventory(TRI) and Factors to Consider When Using TRI Data*, at 2 (2002), *available at* http://www.epa.gov/tri/2002_tri_brochure.pdf.
[22] National Transportation Safety Board, Derailment of Canadian Pacific Railway Freight Train 292-16 and Subsequent Release of Anhydrous Ammonia Near Minot, North Dakota, at 50 (March 9, 2004), *available at* http://www.ntsb.gov/publictn/2004/rar0401.pdf.

[23]Richard A. Falkenrath, *We Could Breathe Easier*, Washington Post, March 19, 2005, at A15.
[24]This sidebar is adapted from a previous report by the Center for American Progress and OMB Watch, *Special Interest Takeover*, May 2004, available at http://www.americanprogress.org/site/pp.asp?c=biJRJ8OVF&b=81986.
[25] James V. Grimaldi and Guy Gugliotta, *Chemical Plants Are Feared as Targets*, Washington Post, December 16, 2001, at A1.
[26]Environmental Defense, Eliminating Hometown Hazards: Cutting Chemical Risks at Wastewater Treatment Facilities, at 4 (December 2003), *available at* http://www.environmentaldefense.org/documents/3357_EliminatingHometownHazards.pdf.

Table 1
Twenty Acutely Toxic Chemicals and their Quantities Used in Commerce

Chemical Name	Production (million lbs. per year)
Ammonia (anhydrous)	31,697
Chlorine	30,836
Nitric acid (concentration of 80% or greater)	22,469
Ethylene oxide	9,190
Propylene oxide	4,980
Hydrochloric acid (anhydrous)	4,942
Phosgene	4,294
Vinyl acetate	3,730
Acrylonitrile	3,650
Hydrocyanic acid	1,937
Sulfur dioxide (anhydrous)	964
Hydrofluoric acid (concentration of 50% or greater)	835
Phosphorus trichloride	718
Bromine	715
Phosphorus oxychloride	88
Dimethyldichlorosilane	N/A
Hydrogen sulfide	N/A
Methyl mercaptan	N/A
Methyltrichlorosilane	N/A
Trichlorosilane	N/A

N/A = Not available. The databases we consulted did not include this information.

Table 2
Chemical Summaries

The following chart summarizes the adverse health effects caused by exposure to the 20 worst chemicals, along with the predominant uses of these chemicals in commerce.

Information for these chemical summaries was obtained from several public sources including: (1) the chemical profiles published by Schnell Publishing available at www.chemexpo.com, (2) information developed by Cambridgesoft.com available at www.chemfinder/cambridgesoft.com (3) product focus report published by Chemical Week available at http://www.chemweek.com/marketplace/prod_focus.html, (4) ATSDR fact sheets, (4) New Jersey Department of Health (NJDOH) chemical fact sheets http://www.state.nj.us/health/eoh/rtkweb/rtkhsfs.htm#C, (5) EPA profiles at http://www.epa.gov/ceppo/ehs/ehsalpha.html.

Chemical Description and Acute Health Effects	Uses
Ammonia: Colorless gas with a penetrating, pungent suffocating odor detectable at 17 ppm; can be a liquid when under pressure, also as an aqueous solution. It dissolves easily in water and evaporates quickly. Exposure to high concentrations of ammonia in the air may cause severe burns on skin, eyes, throat, and lungs. In extreme cases, blindness, lung damage, heart attack, or death occur. Higher concentrations can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Fertilizer 72%; Ammonium nitrate explosives 4%; Fiber and plastic intermediates 7%; Miscellaneous, 14%.

Chemical Summaries (continued)

Chemical Description and Acute Health Effects	Uses
<u>Chlorine:</u> Amber liquid or greenish-yellow gas with characteristic irritating, bleach-like odor detectable at 0.02 to 3.4 ppm. Chlorine is corrosive and may be converted to hydrochloric acid in the lungs. Signs and symptoms of acute exposure to chlorine may include tachycardia (rapid heart rate), hypertension (high blood pressure) followed by hypotension (low blood pressure), and cardiovascular collapse. High exposures can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Polyvinyl chloride, 37 %; Other organic chemicals, 25 %; Inorganic chemicals, 17 %; Water treatment, 6 %; Pulp and paper, 5 %; Miscellaneous, 10 %.
<u>Nitric Acid:</u> Colorless, yellow, or red fuming liquid with an acrid, suffocating odor detectable at <5.0 ppm. High exposures can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Ammonium nitrate, 75 %; Adipic acid, 9 %; Nitrobenzene, 4 %; Toluene diisocyanate (TDI), 4 %; Miscellaneous, 8 %.

Chemical Summaries (continued)

Chemical Description and Acute Health Effects	Uses
Ethylene Oxide: Colorless liquid or gas with an ether-like odor detectable at 257 to 690 ppm; irritating at high concentrations. Higher levels of exposure cause vomiting, memory loss and numbness, as well as a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Ethylene glycol, 57 %; Ethoxylates (surfactants), 11 %; Ethanolamines, 11 %; Diethylene, triethylene and polyethylene glycols, 9 %; Glycol ethers, 7 %; Miscellaneous, 5 %.
Propylene oxide: Colorless liquid with an ether-like odor. Repeated exposure can damage lungs and/or lead to pneumonia.	Flexible and rigid urethane foams, 58 %; Propylene glycols, 22 %; P-series glycol ethers, 5.5 %; Di- and tripropylene glycols, 3.5 %; Miscellaneous, 11%.
Hydrochloric acid [Hydrogen chloride]: Colorless gas with an irritating, pungent odor. Breathing can severely irritate the lungs. Higher exposures can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Chemicals production, 30 %; Steel pickling, 20 %; Oil well acidizing, 19 %; Food processing, 17 %; Miscellaneous, including water treatment, 14%.

Chemical Summaries (continued)

Chemical Description and Acute Health Effects	Uses
<u>Phosgene:</u> Colorless liquid or gas with a sweet odor like hay at low concentrations, sharp pungent odor at high concentrations; detectable at 0.1 to 5.7 ppm. A chemical warfare agent, causing severe pulmonary edema but not always immediately irritating.	Toluene diisocyanate, 40 %; MDI/polymeric isocyanates, 40 %; Polycarbonate resins, 13 %; Miscellaneous, 7 %.
<u>Vinyl acetate</u>: Clear, colorless liquid with pleasant, sweet to sharp irritating odor. Irritates nose, throat and lungs causing coughing and shortness of breath. High levels can cause fatigue, irritability, disturbed sleep, dizziness and lightheadedness. May affect heart, nervous system and liver.	Polyvinyl acetate emulsions and resins, 56 %; Polyvinyl alcohol (PVOH), 18 %; Polyvinyl butyral (PVB), 11 % Ethylene-vinyl acetate (EVAc) resins, 8 %; Miscellaneous, 7 %.
<u>Acrylonitrile:</u> Colorless to pale yellow liquid with a mild pyridine- onion- or garlic-like odor at 2 to 22 ppm. It can be dissolved in water and evaporates quickly. Exposure to high concentrations in the air will cause nose and throat irritation, tightness in the chest, difficulty breathing, nausea, dizziness, weakness, headache, impaired judgment, and convulsions. Higher concentrations can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Adiponitrile (nylon production), 33 %; Acrylic fibers, 25 %; ABS/SAN resins, 23 %; Acrylamide, 9 %; Nitrile elastomers, 3 %; Miscellaneous, 7 %.

Chemical Summaries (continued)

Chemical Description and Acute Health Effects	Uses
<u>Hydrocyanic acid [Hydrogen cyanide]</u>: Colorless or pale blue liquid or gas with a bitter almond odor detectable at 1 to 5 ppm. Dizziness, headache, pounding of the heart, trouble breathing and nausea. These can rapidly lead to convulsions and death.	Adiponitrile (nylon 6/6), 47 %; Acetone cyanohydrin, 27 %; Sodium cyanide, 8 %; Methionine, 6 %; Chelating agents, 2 %; Cyanuric chloride, 2 %; Miscellaneous, 8%.
<u>Sulfur Dioxide</u>: Colorless liquid or gas with a characteristic, pungent odor detectable at 0.3 to 5 ppm, can be a liquid at < 14 degrees F. Preservative, disinfectant, bleaching agent and antioxidant. Irritates nose, throat and lungs causing coughing and shortness of breath. Higher exposures can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Chemicals, 40 %; Pulp and paper, 23 %; Food and agriculture (mainly corn processing), 14 %; Water and waste treatment, 9 %; Metal and ore refining, 6 %; Miscellaneous, 8 %.
<u>Hydrofluoric acid [Hydrogen fluoride]:</u> Colorless, fuming liquid or gas with a strong, irritating odor. Breathing can irritate the lungs and cause shortness of breath. Higher exposures can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Fluorocarbons, 60 %; Chemical derivatives, 18 %; Aluminum manufacturing, 6 %; Stainless steel pickling, 5%; Petroleum alkylation catalysts, 4 %; Miscellaneous, 7 %.

Chemical Summaries (continued)

Chemical Description and Acute Health Effects	Uses
Phosphorus trichloride: Colorless to yellow, fuming liquid with an odor like hydrochloric acid. High exposures can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Pesticide intermediates, (particularly glyphosate) 65 %; Phosphorus oxychloride, 15%; Phosphorous acid (primarily for water treatment chemicals), 10 %; Miscellaneous, 10%.
Bromine: Heavy, red-brown, fuming liquid with a choking, irritating odor, causes tears. Odor can be detected at concentrations as low as 0.05 ppm. High exposures can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Flame retardants, 40 %; Drilling fluids, 24 %; Pesticides (mostly methyl bromide), 12%; Water treatment chemicals, 7 %; Miscellaneous, 17 %.
Phosphorus oxychloride: Volatile, colorless to pale yellow, strongly fuming liquid.	Phosphate esters, 85 % (flame retardants and plasticizers for plastics and urethanes); Miscellaneous, including pesticides and lube oil additives, 15 %.
Dimethyldichlorosilane: Violent reaction with water and alcohols. Breathing can irritate the lungs and cause shortness of breath. Higher exposures can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Chemical intermediate for the manufacture of silicone.

Chemical Summaries (continued)

Chemical Description **and Acute Health Effects**	**Uses**
<u>Hydrogen sulfide</u>: Colorless gas with a strong odor of rotten eggs detectable at 0.001 to 0.1 ppm; liquid at high pressure, low temperature. Nausea, dizziness, confusion headache. High concentrations cause immediate death, through the nervous system resulting in paralysis of respiratory centers.	Used in the manufacturing of chemicals; in metallurgy; analytical reagent; agricultural disinfectant; intermediate for sulfuric acid, elemental sulfur, sodium sulfide, and other inorganic sulfides; additives in extreme pressure lubricants and cutting oils; and as an intermediate for organic sulfur compounds.
<u>Methyl mercaptan:</u> Colorless gas with a disagreeable odor like garlic: can be liquid at <43 ˚ F. Breathing high concentrations causes headache, nausea, vomiting, dizziness, muscle weakness, and loss of coordination. Higher concentrations can cause loss of consciousness and death by respiratory paralysis and pulmonary edema.	Used in manufacturing of pesticides, plastics and pharmaceuticals, and as a gas odorant to serve as a warning property for odorless but hazardous gases.
<u>Methyltrichlorosilane:</u> Colorless liquid with acrid odor. High exposures can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	Chemical intermediate for the manufacture of silicone.

Chemical Summaries (continued)

Chemical Description **and Acute Health Effects**	**Uses**
<u>Trichlorosilane:</u> Colorless liquid with acrid odor fumes in air, supports combustion. Irritates nose, throat and lungs causing coughing and shortness of breath. Higher exposures can cause a build up of fluids in the lungs (pulmonary edema), a medical emergency with severe shortness of breath.	N/A

N/A = Not available. The databases we consulted did not include this information.

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