STRATEGIC MATERIALS

ABSTRACT

This is a comparative study of national strategic materials policy from the perspective of U.S. national security and, therefore, contains a certain bias. The Committee concentrated on the traditional material of steel and aluminum and on the advanced materials of ceramics, polymers, composites, and the "smarts." The findings fall into three broad categories. First, The United States, Canada, and the European Union still have the remnants of the Cold War's (1945–1989) strategic materials policy.[1] Second, Belgium, Poland, and Spain are conscious of the strategic nature of selected materials, but appear unsure as to "who" in their country or region can be the most reliable provider of strategic material products. Third, there is a general recognition that the return of the "global commons;" the occasional natural disasters; the apparent world climate changes; the pollution of the habitat; and the growth, urbanization, and migration of the world's population directly affect all aspects of the entire life cycle of minerals, metals and materials, both traditional and advanced.

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INTRODUCTION

In its comparative study of strategic materials, the Committee took the national policy approach. National policy is composed of five interrelated components: (1) a statement of national goals and objectives; (2) a strategy or means for achieving the goals; (3) a set of national priorities to guide the allocation of financial and personnel resources; (4) a set of criteria by which to assess the progress toward goal achievement; and (5) the designation of the individual or agency fully responsible for the success of the policy and its supporting programs and projects.[2]

Associated with the domain of strategic materials, both tradition and advanced, are 13 major policy issues:

1. Funding basic research in the material sciences and technologies.
2. Educating material scientists and engineers.
3. Developing design standards and product reliability criteria.
4. Protecting intellectual property rights and trade marks.
5. Maintaining worker health and safety standards in mining, metal processing, manufacturing, and disposal.
6. Collecting essential data and information on mining and material industries, such as iron ore and bauxite, steel and aluminum.[3]
7. Transferring defense material sciences and technologies to the civil sectors.
8. Depending on offshore sources for strategic materials and associated technologies, trading blocs included.
9. Accessing seabed material and energy resources.
10. Recovering, reclaiming, and recycling used metals and materials.
11. Stockpiling selected strategic materials and precursors.[4]
12. Controlling the export of selected strategic materials and associated technologies.
13. Substituting advanced materials for traditional materials in high performance systems.

Accomplishments in most of these material policy issues involve the United States and other countries in a host of arrangements and regulatory program at the federal government level with such multistate agencies as the Food and Agriculture Organization (1945; Rome), the International Labor Organization (1946: Geneva), the International

Organization for Standardization (1947: Geneva), and the International Bank for Reconstruction and Development (1947: Washington).

The national policy perspective, the attending material policy issues, and the requirement to participate in and comply with a host of regional and world regulatory regimes demonstrates the need for a national materials policy based on the security interests of the United States and its Allies.[5]

DEFINITION OF THE STRATEGIC MATERIALS INDUSTRY

Over the years, during national emergencies, wartime, or economic depressions various materials have become "strategic." The strategicness of a material is in part a function of it essentially and its availability. As an example, as of 30 September 1997, the National Defense Stockpile was composed of 88 materials in five material types valued at $5.4 billion. Of the five material types 22 percent were minerals, 8 percent were agriculture products, 20 percent were ores, 36 percent were metals, and 14 percent were classed as "other." Among the metals were aluminum, cobalt, nickel, silver, tin, and zinc. Included with the agricultural products were natural rubber and tannin extract. Each of these 88 materials constitutes the raw material for or a product of an "industry."[6]

In 1995, the Office of Science and Technology produced a list of "national critical technologies." This list includes 11 subareas of materials characterized functionally: (1) alloys, (2) ceramics materials, (3) composites, (4) electronic materials, (5) photonic materials, (6) high energy-density materials, (7) highway/infrastructure materials, (8) biocompatible materials, (9) stealth materials, (10) superconductors, and (11) aircraft structures.

CURRENT CONDITION

This section will be a sketch of the broad features and factors related to the steel industry and to the advanced materials industries.

The Steel Industry

A contemporary description and the current data and information are available from the American Iron and Steel Association (Washington) and from the International Iron and Steel Association (Brussels).[7]

The U.S. steel industry has been and continues to be a solid pillar in the foundations for U.S. commercial prosperity and national power. The

apparent national requirements for steel and steel products in order to update, repair, and modernize the U.S. transportation, energy, communications, housing, and appliance industries are substantial, and the requirements exceed domestic capacity. The U.S. steel industry should be given recognition for its successful efforts to modernize its mills, comply with environmental standards, reduce worker safety and health risks, and meet the needs for high-quality steel at reasonable costs.

During the course of the Committee's study, foreign producers (located in Brazil, Japan, China, and Russia) managed to dump steel and steel products into the U.S. market. According to U.S. law and international trade agreements, dumpling is illegal. The American Iron and Steel Institute, the Congressional Steel Caucus (both House and Senate), the United Steel Workers of America, and others "alerted" the Administration. Members of the 106th Congress introduced legislation, such as the proposed Fair Steel Trade Act and held committee hearings before the "problem" was resolved through public exposure and diplomatic exchanges.

With the creation of the North American Free Trade Agreement, a trade bloc including Mexico, Canada, and the United States, Canadian-made and U.S.–made steel and steel products continue to move across the common border via ship, barge, truck, and train, but on a much larger scale. For the most part, this movement is based on cost, quality, and schedule requirements.

The classical vertical integration model of the steel industry has gone through a dismemberment process in part. Public incorporation, private ownership, proprietary processes, financial accountability, pollution standards, labor compensation, and investment returns are some of the factors contributing to the restructuring of individual transnational corporations. However, even today, each transnational corporation seeks to have ownership of or direct control over the following resources, agencies, and capabilities:

- The land and mines, which produce the iron ore, limestone, coal, and special alloys, used to make steel.
- The transportation systems (ports and ships, barges, trucks, and trains) to move the raw materials from the mines or storage to the steel mills and then the finished steel and related products onto the manufacturing sites.
- The sources of electrical and other energy types to operate mills and to make steel.
- The factories to role, shape, bend, and weld to make steel products, such as plate, beams, and rails.

- The centers to collect and process primary and secondary steel scrape.
- The research and engineering capabilities to maintain currency with the latest mining, metallurgical, manufacturing, and recycling processes.
- The financial institutions to acquire funding and investments for plant modernization, new technologies, and raw materials.
- The executive, administrative and scientific cadres who "know steel" and who can work with all the stakeholders in the "common interest."

Advanced Materials

A number of Washington-based associations, such as the Suppliers of Advanced Composite Materials Association, plus the National Institute of Standards and Technology (Gaithersburg), the Defense Advanced Research Projects Agency, and the Congress' former Office of Technology Assessment, are excellent sources of data and information, domestic and foreign, on the state and development of the advanced materials industries.[8]

This category includes thousands of ceramics, polymers, and composites that are created and designed to meet unusual performance requirements (e.g., speed and endurance, fatigue and radiation, stealth and weight) for manned or unmanned, civil or military, operational systems in the lithosphere, hydrosphere, atmosphere, biosphere, or space. Most of the basic ingredients and material precursors for advanced materials are readily available. However, the science and technology with the associated creativity, invention, innovation, and transfer processes, the individuals and scientific teams, are critical in order to obtain the desired "fix, form, and function." Much proprietary work is associated with advanced materials development and usage.

While each advanced material has peculiar research and development protocols and arrangements, there is a general scheme for advanced materials development. Eight broad, interrelated stages have been identified:

1. An expression of the desired performance requirement stated often as a hypothesis or as an actual need.
2. The "organization" of a team of those scientists and engineers who are interested in the "problem."
3. A systematic search of the scientific and technical literature to identify similar or like problems and their apparent "material"

solutions. (Note: Advanced material conferences and workshops are important.)

4. Use of a laboratory to fix, form, and function potential advanced material candidates and for extensive testing and evaluation.
5. The testing of the "solutions" in the operational environment (such as the hydrosphere) to ascertain the actual performance of each candidate material. Select the "solution."
6. Design a prototype factory for either the batch production process or the continuous production process of the selected advanced material. Conduct an operation test of the factory with attention to worker health and safety, pollution of the environment, and consistency of product quality.
7. Obtain the necessary patent rights, trademarks, and technical agreements.
8. Build a factory, purchase and store precursors, hire and train a workforce, and go into production.

Much of the basic research and development work outlined in the preceding is done in governmental, academic, and small commercial laboratories because of the length of time normally to go from the "problem" to the patents. The European Union appears to have taken a more consistent and comprehensive approach to organizing and supporting the "seeds" for future advanced material industries. The leadership of the European Union is conscious of the continent's dependence on offshore sources (especially from Africa and South America) for more traditional materials, and therefore it seeks to have alternatives (synthetics and substitutes) on line or in hand.

The three major policy issues that deal with advanced materials are:

1. The most effective legal means to protect intellectual property, such as the use of patents, trademarks, and proprietary agreements.
2. The large investment and extended time period needed to do the research, development, testing, evaluating, and manufacturing of new advanced materials.
3. The importance of a yeasty and viable home-based research capability in the broad material sciences arena, not only to foresee and handle the "problems," but also to conceptualize the proved "solutions:" the fixes, the forms, and the functions.

CHALLENGES

There are numerous security and commercial challenges confronting the United States and its Allies. The Committee was in Europe while there were undeclared wars under way in the former Yugoslavia. Also, during its study, both India and Pakistan exchanged nuclear "bomb" detonations in South Asia. Generally, all the challenges can be summarized under three broad sets.

One set of challenges deals with access to materials. This includes such major issues as the many conflicting territorial claims in the South China Sea, the unresolved issue as to who now owns the mineral sources of the Republic of South Africa, the safe storage and sure accounting of spent nuclear fuels, the future implications for the many regional trade blocs, and the developing shortages of potable drinking water. Imagine the problems, prospects, and challenges when fresh drinking water becomes a strategic material.

Another set of challenges deals with the acts of Nature, such as regional droughts, hurricanes and typhoons, volcanic eruptions, earthquakes, and regional floods.

A third set of challenges involves human problems. Throughout the world there are terrorist organizations, ethnic conflicts, criminal corporations, extensive poverty, and something called "kleptonomics."

GOVERNMENT GOALS AND ROLE

Over 200 years ago, the federal government got the tasks to "provide for the common defense and insure the general welfare." The federal government has had and will continue to have a vital role to play in the traditional materials as well as the advanced materials areas. The lessons of the Great Depression (1929–1939), the Second World War (1939–1945), and the Cold War Period (1945–1989), including the Berlin Airlift, the Korean Conflict, and the Vietnamese War have not been forgotten. "Preparedness" is the watchword. In this day and age, preparedness means to build "national power." Clearly, common material resources (e.g., wheat, soybeans, tar sands, water) in general and strategic materials (e.g., steel, aluminum. cobalt, titanium, and guayule rubber of Aztec origin) in particular are vital factors and components in both the foundations and then instruments of national power.

As well known, the components of national power include (a) extensive territory, (b) natural resources, (c) large population, (d) advanced technology, (e) social cohesion, (f) national will, (g) sufficient

provisioning, and (h) effective government. In turn, the natural resource component consists of (a) typography, (b) hydrography, (c) climate, (d) minerals, (e) flora, (f) fauna, and (g) soils. From the most simple tasks of issuing patents and trade marks, upholding standards of weights and measures, enforcing the mining laws, regulating the polluters, and ensuring labor safety standards to the far more complex activities of funding material research programs and promoting material advancements in construction, transportation, communications, and health care, the federal government will continue its role in the promotion, development, and application of strategic and advanced material resources in the national interest.

Perhaps the thrice themes of "awareness," "preparedness," and "responsibility," for the United States are captured and demonstrated by the many acts passed by the Congress, signed by the President, and implemented by a federal agency. Some examples of these acts in chronological order include the Mineral Lands Leasing Act of 1920, the Reconstruction Finance Corporation Act of 1932, the Strategic Materials Act of 1939, the Defense Production Act of 1950, the Mining and Minerals Policy Act of 1970, the Strategic and Critical Materials Stockpiling Act of 1979, and the Critical Materials Act of 1981. On June 6, 1994, the Administration issued Executive Order 12919, "National Defense Industrial Resources Preparedness," which continues this thrice thematic approach.

RECOMMENDATIONS

Recommendation One. Within the United States alone, there are many stakeholders in the materials arena writ large: individual inventors, colleges and universities, local and state governments, labor and professional associations, and commercial companies, as well as Congressional committees and federal departments and agencies. Given the ongoing global political conditions and regional commercial disruptions, the time has come again for all the stakeholders (read: representatives of the citizens) to gather in a series of annual conferences to reformulate a national materials policy to serve the national interest. The five components of national policy and the 13 material policy issues, as outlined, could well serve as an agenda. This will not be an easy task, but it is an essential task.

Recommendation Two. There is a "politics of global resources." The center stage is the United Nations, which has some 185 members. The main thrust of most of these members is to restore the "global commons." Through a series of international and regional arrangements

and conventions, there is the effort to "manage" global resources in the interest of humankind as a whole. The time has come again for the United States to take the lead to attempt to formulate a global materials policy in the interest of humankind, now and in the future. The Antarctic Treaty (1961) and the United Nations Convention on the Law of the Sea (1994) are a start, but more needs to be done on the mining, metals, and materials resources areas.

CONCLUSION

The world is and will continue to be a hostile environment for the United States and its Allies. The primary task is to think and reason strategically, meaning the survival of the United States and security of its citizenry. The only practical approach to achieve this political condition is to build national power whose instruments will guide the regional and global forces of change toward a more peaceful and sufficient sustainable development process. One of the key foundations of national power is material resources. Minerals are where you find them. Minerals are nonrenewable resources. Everything is made of something. Organizing and managing the foundations of national power (as listed earlier) and in turn forging and employing the instruments of national power (diplomatic, technological, military, and commercial) do not happen by chance. There is now and will continue to be an essential role for the federal government in the materials arena, as well as in the other foundations of national power.

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[1] Still useful in taking a policy perspective is: Norman Wengert, *Natural Resources and the Political Struggle* (Garden City, Doubleday & Company, 1955).

[2] See for examples: Ministry of Natural Resources Canada, "The Minerals and Metals Policy of the Government of Canada: Partnership for Sustainable Development," (Ottawa: Natural Resources Canada, 1996); and U. S. Department of Defense, "The Relationship of Defense Materials Research and Development to Dependence on Foreign Sources for Critical Materials," (Washington: USDOD, February 1999).

[3] Essential data and information on important minerals, metals, and materials can be found in such publications as: U. S. Bureau of Mines, *A Regional Assessment of Selected Mineral Commodities in Subequatorial Africa* (Washington, DC: Government Printing Office, September 1991); Canadian Intergovernmental Working Group on the Mineral Industry, "Overview of Trends in Canadian Mineral Exploration," (Ottawa: Natural Resources Canada, September 1996); and United States Geological Survey, *Mineral Commodity Summaries, 1998* (Washington, DC: Government Printing Office, 1998).

[4] U.S Department of Defense, *1999 Report to the Congress on National Defense Stockpile Requirements* (Washington, DC: USDOD, January 1999).

[5] A good benchmark study which is permeated with material policy issues and the role of participating agencies, at home and abroad, is Office of Science and Technology, *1995 Federal Research and Development Program in Materials Science and Technology* (Washington, DC: The White House, December 1995).

[6] The data are from U.S. Department of Defense, *Strategic and Critical Materials Report to the Congress, Fiscal Year 1997* (Washington, DC: USDOD, 1998).

[7] Two recent studies of the American steel industry are U.S. Department of Energy, *Energy and Environmental Profile of the U. S. Iron and Steel Industry* (Columbia, MD: ENERGETICS, Inc., July 1996); and U.S. Department of Energy, *Steel Industry Technology Roadmap* (Washington, DC: USDOE, August 1997).

[8] The best overall coverage of the advanced material industries is still U.S. Bureau of Mines, *The New Materials Society: Challenges and Opportunities* (Washington: USBOM, 1990), Three Volumes. For a more programmatic approach, consult the Office of Science and Technology, *Advanced Materials and Processing: The Fiscal Year 1993 Program* (Gaithersburg, MD: NIST, 1992).