ALUMINUM
INDUSTRY VISION

Sustainable Solutions

November 2001

Aluminum is ...

- Strong and lightweight
- Repeatedly recyclable for environmental sustainability
- Resistant to corrosion
- Good conductor of heat and electricity
- Tough and non-brittle, even in very low temperatures
- Easily worked and formed, can even be rolled to very thin foil
- Safe for use in contact with a wide range of foodstuffs
- Highly reflective of radiant heat
- Highly elastic (an advantage in structures under shock loads)
- Receptive to coatings
- Attractive in appearance

The Aluminum Vision is intended to stimulate a wide variety of R&D activities to accelerate technology development throughout the industry. A host of R&D approaches are needed to provide a rich and diverse portfolio to meet tomorrow's challenges and opportunities. These approaches may include:

- In-house corporate research
- Collaborative R&D with universities, laboratories, and research consortia
- Partnerships with manufacturers, suppliers, and customers
- International research coordination
- Broad public-private partnerships

Some of these efforts involve the participation of aluminum companies in cooperative research projects, consistent with applicable antitrust laws and with the free and open competition that is a hallmark of the aluminum industry. All of these approaches make an important contribution to the aluminum industry technology portfolio.

Table of Contents

Executive Summary 1

Aluminum Industry Today 5
- Raw Materials Sector 5
- Semifabricated Sector 9
- Finished Product Sector 9
- Industry-wide 11

Future Trends 13
- Markets 13
- Aluminum Supply Chain 16
- Sustainability 16
- Production 17
- Manufacturing 18
- Energy 19
- Human Resources 20

Vision of the Aluminum Industry 21
- Products and Markets 21
- Sustainability 21
- Energy and Resources 22
- Technology 22
- Education and Outreach 23
- Human Capital 24

Implementation Strategy 25
- Achievements 1996-2001 26
- Partnerships and Progress 27
- Participants 29
- Building the Future 31

Process and Acknowledgments 33

Executive Summary

Aluminum is one of the most versatile and essential materials for our dynamic global economy. Its strength, conductivity, recyclability, and light weight make it ideally suited to the needs of a highly mobile and technologically sophisticated world. Above all, aluminum has emerged as the most environmentally sustainable material available to our increasingly resource-conscious planet. It offers customers a clear advantage through its ability to be repeatedly recycled without loss of quality and with only five percent of the original process energy use and emissions. On a life-cycle basis, aluminum exceeds the energy and environmental performance of competing materials in virtually all applications—and will totally offset the environmental footprint of its original manufacture.

*By 2020, the North American aluminum industry will be universally recognized as a **world leader** in providing innovative, material-based **solutions** that build on aluminum's intrinsic **sustainability** and deliver **superior value** to users.*

As we begin the 21st century, the aluminum industry seeks to expand applications by focusing on complete material and engineering solutions that meet specific user needs. By emphasizing the functionality of products and their applications, manufacturers will capitalize on aluminum's unique attributes, using it by itself or in combination with other materials to create superior products. In the process, aluminum companies and their customers will dramatically change how their products are designed and used.

This document presents the first update to the aluminum industry vision, *Partnerships for the Future*, published in 1996. The original vision set the framework for the industry's first technology roadmap and for the past five years has been instrumental in advancing aluminum research and development (R&D). The roadmap, which outlines a comprehensive aluminum R&D agenda, was translated into several languages, reinvigorated interest in aluminum technology development worldwide, and led to the development of four more focused roadmaps. These landmark documents have helped to focus public and private R&D resources on industry-defined priorities and have permanently altered the industry and its approach to R&D.

In the mid-1990s, the industry acknowledged that it needed to improve its fundamental processes to compete successfully in global markets. While the necessary improvements would benefit the industry, many would also help achieve national goals for energy and the environment. Traditional technology development processes, including R&D planning and portfolio management, began evolving to increase the economic efficiency of technology

development and speed the path to commercialization. The vision and roadmaps catalyzed the industry's efforts and helped attract a wide range of resources from the federal government, national laboratories, universities, suppliers, customers, and others. This pooling of technical and financial resources by diverse stakeholders has markedly increased the quality, efficiency, and pace of aluminum technology development. Federal support, particularly from the U.S. Department of Energy's Industries of the Future program, has helped to accelerate the development and deployment of aluminum technologies critical to public and strategic national interests.

Five years later, a substantial portion of aluminum R&D involves some form of collaboration. Such partnerships today are tackling ambitious projects in advanced cell design, intelligent sensor and control systems, secondary melting, forming and casting, advanced recycling, reuse of wastes, and other areas of broad benefit to the aluminum industry and the world. Since 1996, the roadmaps have directly stimulated well over $100 million worth of cost-shared R&D projects with over 75 different companies, universities, national laboratories, suppliers, and other partners.

The aluminum industry today is similar in many ways to the industry that existed in 1996, but it is also profoundly different. Enhancements and recent technology advances in production, processing, fabrication, and recycling have increased the industry's energy efficiency, reduced waste and emissions, and improved productivity. On the emissions front, new technologies and processes have helped the industry cut its perfluorocarbon (PFC) emissions by more than half since 1990. Technology advances are also enabling aluminum to flourish in many application areas, displacing traditional materials in many sectors. The U.S. auto industry, for example, uses over 50 percent more aluminum today than it did in 1995. Aluminum is expected to surpass plastic in the upcoming model year to become the third-most-used material in light vehicles.

At the beginning of this new century, the aluminum industry faces unprecedented challenges and opportunities. Our affluent, diverse, and mobile society demands safe, durable, environmentally responsible, and highly sophisticated products. Tremendous technological advances in processing have increased expectations of better products and services at lower prices and have generated a need for new engineering and scientific expertise in the industry. The industry's traditional supply chain is realigning itself to focus on material transformation issues upstream and on functionality downstream. The industry will need to work with customers who are less interested in purchasing materials and more interested in solving product design problems. Sophisticated aluminum processing technologies will require a highly trained and educated work force. Safe and efficient transportation and infrastructure networks need expansion or rebuilding around the globe, and other lightweight materials are challenging aluminum in some of its traditional applications. Overall, it is a time of great economic, political, and strategic uncertainty.

The North American aluminum industry has a clear vision to effectively address the challenges and opportunities of the coming decades. By 2020, the aluminum industry will be universally recognized as a world leader in providing innovative, material-based solutions that are environmentally sustainable and deliver superior value to users. The industry's

highly trained work force will use aluminum's light weight, strength, recyclability, and conductivity to provide engineered solutions for a global society that values energy efficiency and sustainability. The industry will build on its already impressive credentials by maintaining the highest recycling rate of all materials, providing a net energy benefit to aluminum use over its entire life cycle, and producing zero net emissions on the same life-cycle basis.

To accomplish its vision, the industry will achieve specific goals in six areas, as described in the box at right. Toward this end, the industry has set forth a six-point implementation plan:

- Use **roadmaps** to identify specific needs and attract resources.
- **Leverage resources** among all stakeholders through broad R&D partnerships.
- Recognize the continuing importance of **all forms of R&D** efforts conducted by aluminum companies either individually or with partners.
- Aggressively promote **communications and outreach** to highlight aluminum's sustainability and life-cycle benefits.
- Promote rapid **deployment** of efficient technologies.
- Strengthen the industry's **education and work force** by launching major educational initiatives to prepare and attract top students and to reach out to an increasingly diverse work force.

The purpose of this document is not to predict the future, but to look ahead and better understand the forces likely to affect the aluminum industry and its customers in the decades to come. In planning for the future, the industry increases its ability to respond successfully to emerging challenges and capitalize on new opportunities. By all indications, the

Aluminum Industry Goals

Products and Markets

- Deliver superior value in engineered material solutions tailored to customer needs.

Sustainability

- Exceed the recycling rate of all other materials and establish the industry as a leader in sustainability.
- Make a positive net impact on the environment over the life cycle of aluminum products.
- Produce zero net emissions of greenhouse gases on a life-cycle basis.

Energy and Resources

- Meet or exceed a target of 11 kWh/kg for smelting and achieve additional energy targets established by industry roadmaps.
- Generate a net energy advantage over the life cycle of aluminum products.

Technology

- Achieve universal recognition as a technology leader applying cutting-edge technology to create innovative products, improve the environment, and contribute to economic growth.
- Aggressively seek out technical innovations in other industries and apply them to improve aluminum processing and products.

Education and Outreach

- Achieve broad public understanding and acceptance of the life-cycle value of aluminum, its key role in technology innovation, and its essential contributions to modern lifestyles.
- Fortify academic programs to develop and attract top science, engineering, and business graduates.

Human Capital

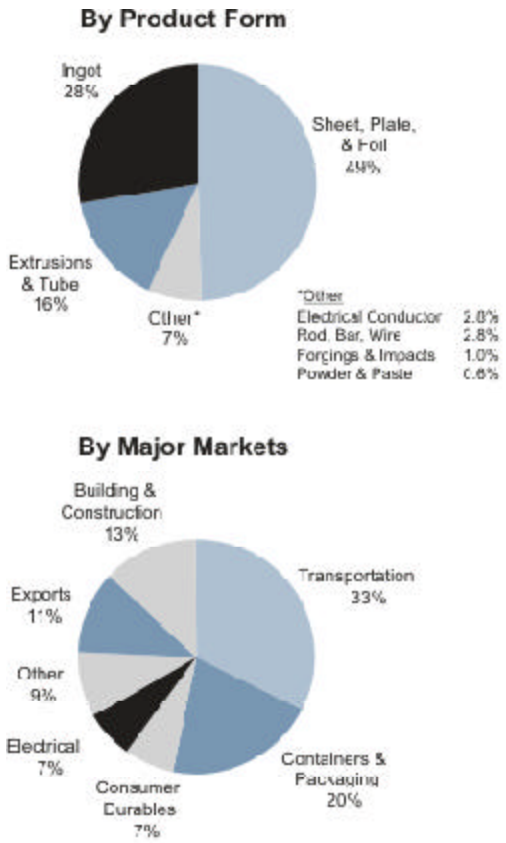
- Employ one of the most highly skilled and best educated work forces in the process industries—one that reflects the population's cultural and linguistic diversity.
- Exceed the health and safety records of all similar processing industries.

aluminum industry is ideally situated to provide the material solutions that the world will need in the 21st century. This document provides the framework for future growth and encourages a variety of R&D approaches for ensuring a healthy and sustainable North American aluminum industry.

Aluminum Industry Today

Since aluminum was first commercially produced just over 100 years ago, the North American aluminum industry has evolved from limited production of products and alloys to high-volume manufacture of a wide variety of products. Today's U.S. aluminum production includes roughly 4.8 million tonnes of flat-rolled products, 2.7 million tonnes of foundry castings, 1.8 million tonnes of extrusions and tube, and nearly 1.0 million tonnes of products in other forms.[1] These products are used in a wide variety of markets, including building and construction, transportation, and packaging, as shown in Figure 1.

Figure 1
U.S. Aluminum Shipments, 2000
(Including Imports)
11.1 Million Tonnes



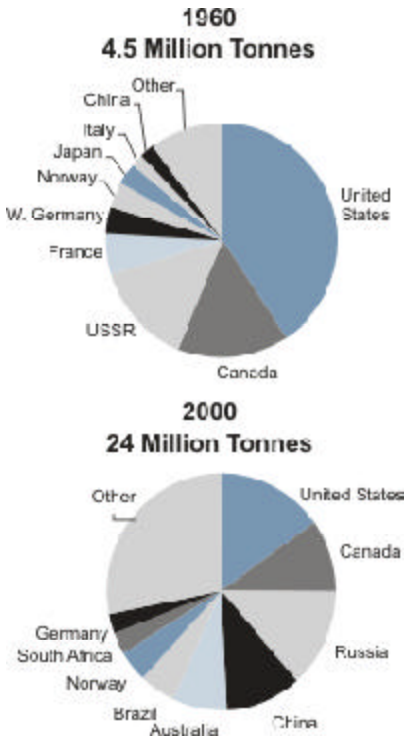
As a lightweight, high-strength, and recyclable structural metal, aluminum has played and will continue to play an important role in a healthy economy. Applications for aluminum and aluminum alloys and composites are expanding into many sophisticated and technologically advanced products.

The trends that have affected the aluminum industry in North America during the past 40 to 50 years reveal many of the driving forces that will shape the future. Although the three industry sectors (raw materials, semi-fabricated products, and finished products) are closely coupled, each has had its own unique influences.

Raw Materials Sector

In 2000, 11 companies operated 23 primary aluminum reduction plants in the United States and produced shipments worth $6.1 billion. While the United States remains the largest producer of primary aluminum metal in the world, its position in this industry sector diminished significantly during the past two decades as China, Australia, and Brazil emerged as major producers in the early 1980s. Figure 2 shows a comparison of the distribution of world primary aluminum production from 1960 to 2000. In the beginning of this period, North American production accounted

Figure 2
World Primary Production

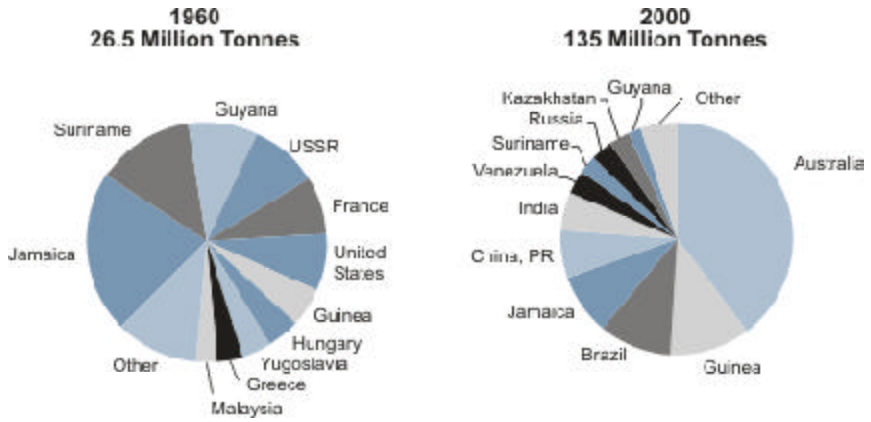


for over half of the world's primary aluminum production. By 2000, its share of world production had dropped to roughly one quarter. The factors behind this decline include bauxite supply, energy costs, world supply, regulatory policies, and a general shift in the structure of the North American economy.

The Quality and Quantity of Bauxite – Bauxite is the raw material from which alumina is refined using the Bayer process. High-grade bauxite deposits have been depleted in the United States and new ones developed overseas, with the result that the United States is now dependent on foreign sources for metallurgical-grade bauxite. Figure 3 shows the shift away from domestic production over the past 40 years. Non-bauxite resources for making aluminum are abundant in the United States, but no processes for using these resources are economically competitive with those that use bauxite. World bauxite resources are sufficient to meet world demand well into the current century.[2]

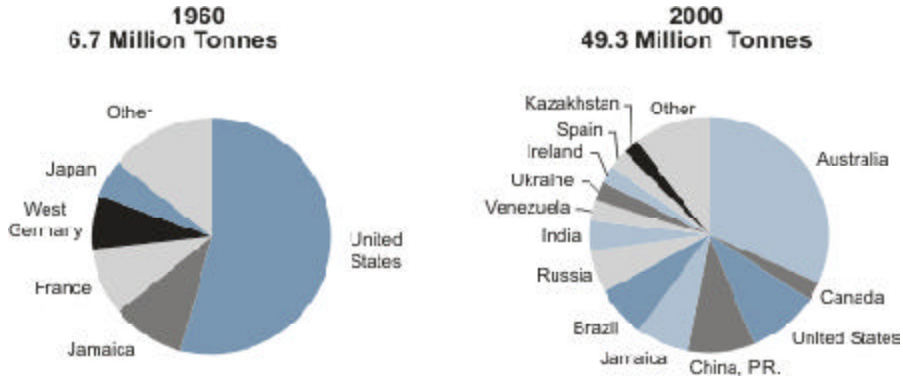
Current U.S. imports of metallurgical-grade bauxite are from Australia, Guinea, and Jamaica. This raw material is processed by refineries in Louisiana, Texas, and Canada. Since the U.S. supply of alumina is insufficient to meet the demand of primary metal smelters, the United States imports alumina and aluminum to supplement domestic production.

Figure 3
World Bauxite Production



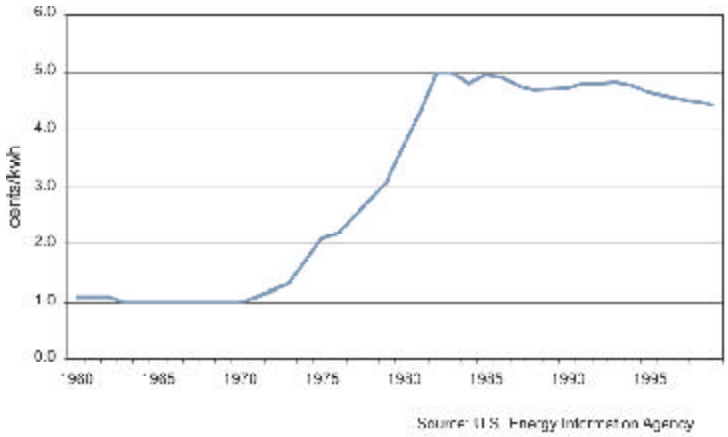
The geographic shift in bauxite mining to overseas locations has encouraged a corresponding shift in alumina production. Figure 4 shows the change in distribution of world alumina production during the past four decades.

Figure 4
World Alumina Production



Energy Costs – Energy is a major component of the total cost of producing aluminum. The decreased availability and higher cost of energy in the United States have restricted the ability of the domestic aluminum industry to compete against those regions of the world where energy resources are readily available at low cost. Figure 5 shows that the average cost of electricity to U.S.-based industrial firms increased by nearly a factor of five from 1972 to 1982, forcing U.S. aluminum companies to close plants with high operating costs and low energy efficiencies in the early 1980s. Although electricity prices decreased slightly between the mid-1980s and 2000, severe spikes occurred on the West Coast in late 2000 and 2001, causing the shutdown of almost all aluminum capacity in the Pacific Northwest and reducing production there by roughly 1.8 million tons. The Bonneville Power Administration, in light of rising natural gas prices and its drought-stricken hydrogenerators, plans to impose a significant wholesale power rate boost when new contracts take effect in October 2001.

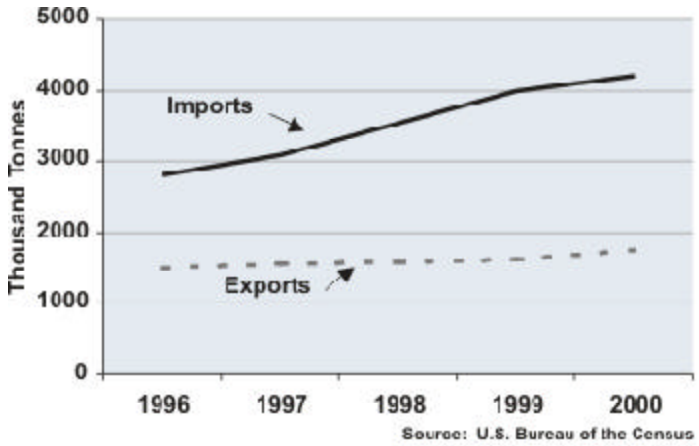
Figure 5
Retail Price of Electricity to Industrial Users
1960-1999



Over the past decade, producers had already been working to optimize operations and increase their energy efficiency through better process control and operating practices, including the use of point feeders in smelting. Now, in response to uncertainties in power supply, some aluminum producers may consider investing in distributed generation technologies (e.g., gas turbines, wind power) that could theoretically produce reliable power at affordable rates.[3]

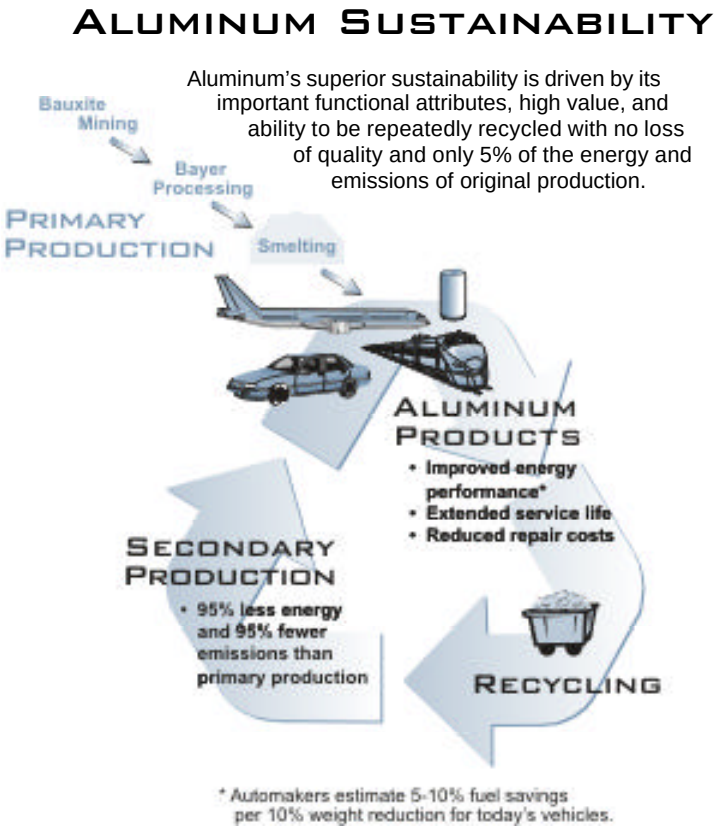
Worldwide smelter expansions and new plant construction have been focused on nations with low-cost energy and labor resources. Northern Brazil, Canada, Venezuela, Argentina, and Russia all have relatively low-cost hydroelectric power available. In addition, countries in the Persian Gulf are using their abundant natural gas reserves to generate electricity to supply smelters. China is expected to become a much larger player as well, once its massive new hydroelectric capacity (under construction) comes on-line.

Figure 6
Aluminum Imports and Exports for Consumption



Increased Supply in World Markets – Beginning in 1991, the aluminum market was faced with rapidly increased exports from the former USSR. Before its breakup, very little Russian metal appeared in Western markets. However, with the emergence of the Commonwealth of Independent States (CIS), many of the historic trading blocks were dissolved, and their aluminum producers searched for new trading partners. By 1992, CIS exports represented about five percent of the world production of aluminum, causing a serious imbalance in world aluminum markets. Although the sudden increase in CIS exports has been accompanied by steadily increasing demand in Western markets, production booms in the Chinese and Middle Eastern aluminum industries could further increase foreign exports.

Aluminum imports to the United States have been increasing steadily since 1996, as shown in Figure 6. Canada and Russia currently account for more than three-quarters of all U.S. aluminum imports.



U.S. Government Regulation and Public Policy – The influence of regulation and policy on the primary aluminum industry has been mixed. Concern for the environment has stimulated a strong interest in expanded use of aluminum by the automotive industry. In particular, rising U.S. CAFE standards and public concern about global warming have spurred efforts to reduce vehicle weight. Since energy consumption is directly related to weight, automobile companies have sought to reduce weight by increasing use of lightweight materials, including aluminum sheet, extrusions, castings, and forgings.

Recycling was instituted early in the history of the aluminum industry both to save energy and because of the high value of recovered metal. More recently, it has also been encouraged by government regulations as a means to conserve resources and reduce waste. As a result, the quantity of aluminum recycled has increased from about 475,000 tonnes in 1960 to about

4,223,000 in 2000. Post-consumer scrap contributed about 40 percent of the aluminum recovered from recycled scrap in 2000. Recyclability must become a serious consideration in the development, specification, and application of new products and their materials systems. This trend is likely to increase as concerns for the ecological sustainability of products and manufacturing processes continue to grow and as the public becomes more knowledgeable about sustainability issues.

To meet increasingly stringent environmental standards, U.S. industries have experienced an increase in capital and operating costs. The 1990 amendments to the Clean Air Act (CAA), the Resource Conservation and Recovery Act (RCRA), and the Clean Water Act all affect the primary aluminum industry. Through public-private R&D partnerships, the industry has made substantial progress in extending pot life and reducing spent potliner waste. In addition, U.S. aluminum companies representing 96 percent of U.S. primary production capacity are participating in the U.S. Environmental Protection Agency's Voluntary Aluminum Industrial Partnership (VAIP) launched in 1995. The goal of the VAIP was to reduce industry emissions of perfluorocarbons (PFCs) by 45 percent (1990 basis) by 2000. Through voluntary improvements to smelting processes and technologies, participating U.S. aluminum companies surpassed that target by achieving a 49-percent reduction in 1999. The industry and EPA have recently agreed to extend the effort to 2005 with a new target to be set by the industry.

Recognizing the global nature of the market, the aluminum industry has traditionally supported lowering tariffs and opening markets for primary metal as well as for semifabricated products. Its position regarding future global negotiations is under development.

Economic Structure – While U.S. primary aluminum production grew steadily in the first 60 years of the 20th century, changes in economic structure have restrained the rate of such growth over the past several decades. One significant change has been the shift in North America toward a service economy and away from manufacturing, with a greater reliance on imports for goods (such as automobiles) that use large quantities of aluminum. This trend has restrained the growth of domestic demand for primary aluminum. A global economic slowdown in 2001 has compounded that effect. Nevertheless, the primary sector has also been affected by the strongly positive trend of increased use of secondary, recycled aluminum in domestic markets.

Semifabricated Sector

Many of the forces that have influenced the primary sector also have had an impact on the producers of semifabricated products. The focus continues to be on increasing productivity and value in aluminum products, and much success has been achieved. Significant advances in aluminum processing technologies such as continuous casting are improving aluminum's cost competitiveness. Incentives for further improvement include the U.S. automotive industry's interest in combining increased use of aluminum with lower life-cycle costs.

Advanced Manufacturing Processes and Technologies – During the past decade, many semifabricated producers have focused their efforts on increasing productivity and reducing the costs of their rolling, forging, casting, and extruding processes. Process simulation models, expert systems, and computer-enhanced manufacturing technologies have been developed and are being widely applied.

Finished Product Sector

The drivers of the primary and semifabricated sectors previously discussed also affect the finished product sector, particularly government regulations and public policy, and advanced manufacturing processes and technologies. The most important forces acting on the finished product sector are the markets in which aluminum competes with other materials.

Throughout its history, aluminum's growth has been fueled by its use as a replacement for existing structural materials. Beginning with its substitution for copper in overhead conductors, aluminum's viability as a cost-effective, high-performance structural material has been most aptly demonstrated by its competitive penetration of markets for beverage containers, transportation, and construction materials.

Container Market – Aluminum beverage cans rose rapidly in popularity beginning in the early 1970s. Can production rose from 29 billion units in 1978 to about 100 billion units in the mid and late 1990s. Amid competition from other materials, the annual growth rate of aluminum shipments to the U.S. container and easy-open end market slowed dramatically between 1990 and 2000 to less than one-tenth the rate of aluminum shipments in aggregate. This market accounts for approximately 5 billion pounds annually, about one-fifth of U.S. industry semifabricated product shipments. While the growth of aluminum consumption in the U.S. packaging industry is slowing and domestic can sheet producers are increasingly looking to offshore packaging markets to provide growth opportunities, the total value of aluminum to the U.S. economy will continue to remain strong.

Automotive Market – Transportation is the largest and fastest-growing market for aluminum. Shipments of aluminum to the U.S. transportation market totaled 3.6 million tonnes in 2000. Automotive aluminum grew from typically less than 100 pounds per vehicle in the late 1970s to an estimated 256 pounds today.[4] Automakers are turning to aluminum to solve automotive design, engineering, and marketing challenges. Lightweight, high-strength aluminum provides the highest safety performance and permits significantly improved fuel economy, thereby reducing greenhouse gas emissions. The *Life Cycle Inventory Report for the North American Aluminum Industry* determined that over the life of a car, aluminum content can actually save much more energy than is needed to produce it in the first place.[5]

Construction Market – In 2000, aluminum shipments to the building and construction market totaled about 1.5 million tonnes. Aluminum is valued in high-rise construction, roofing, facades, windows, shells, doors, curtain walls, beams, and supports. The life span of aluminum in many building and construction applications is on the order of 40 to 50 years or more.

Industry-wide

Globalization has tied the economies of all nations more closely together, so that the direction of the U.S. economy has a greater impact on other nations and vice versa. The rise of larger, and often multinational, corporations has strengthened this connectivity. The mergers of Alcoa Inc. with Reynolds Metals Company and of Alcan Aluminum Limited with the Swiss company Algroup to form Alcan Inc. are examples of this trend. Observers see a strengthening of producer focus on downstream operations and markets.

As in the rest of the economy, increased use of the Internet and e-commerce are profoundly affecting all sectors of the aluminum industry and facilitating increased movement toward just-in-time and lean manufacturing practices. In the finished products sector, electronic communications are drawing the customer and manufacturer closer together to address functional customer needs.

---

[1] The Aluminum Association, *Aluminum Statistical Review for 2000*, 2001.
[2] U.S. Geological Survey, *Mineral Commodity Summaries*, January 2001. Prepared by P.A. Plunkert.
[3] "Economic Turmoil Tests Markets," 2001 *Engineering News-Record*, www.enr.com/new/coverstry_32601a.asp, September 11, 2001.
[4] Ducker Research Co., Inc.
[5] The Aluminum Association, *Life Cycle Inventory Report for the North American Aluminum Industry*, 2001.

Future Trends

The aluminum industry is shaped by economic conditions, market competition, international politics, societal attitudes, geographic distribution of resources, and power costs. Aluminum producers are already adjusting to global markets, e-commerce, energy deregulation, privatization, and new ways of doing business. The industry must continuously look ahead to be able to capitalize on new opportunities presented by change and innovation. The anticipated and continued trends likely to affect the industry over the next 20 years are summarized below.

Markets

More markets will open to free trade. Gradually dismantling international trade barriers will lead to increased globalization, the emergence of new competitors, and better access to foreign markets.

New competitors may emerge. While Russia's significance in the global aluminum industry has declined, the North American industry will continue to be affected by international developments. Increasing competition from other regions, such as the Middle East and Asia, may challenge North America in world markets. The development of major hydroelectric projects in China (plans include up to 125 GW of new hydroelectric capacity by 2010[1]) and possibly Brazil (large projects now under review) would support significant new aluminum capacity, which could compete vigorously with North American producers in some markets.

- **Efficient production and quality are keys to global success.** To compete with foreign producers that enjoy lower energy, labor, and regulatory costs, domestic aluminum companies must improve energy and production efficiencies and offer products and services of superior quality and functionality.

Industry growth hinges on successful materials competition, substitution, and integration. Industrial customers routinely substitute one material for another to seek competitive advantage. Opportunities and margins will vary throughout the aluminum value chain, with the best opportunities reserved for components that provide multiple benefits and, therefore, enhance value over other material options.

- **Best opportunities are in applications for which aluminum offers multiple benefits.** Aluminum has been successful in automotive markets because it provides multiple benefits: improved safety, handling, fuel efficiency, and environmental performance. Aluminum's relative abundance and proven performance may open further opportunities for it to displace copper, zinc, lead, steel, plastics, and wood.[2]
- **Competition among materials will continue**. While competing materials may threaten to displace aluminum in some traditional applications, aluminum's sustainability characteristics may give it an edge over magnesium, concrete, titanium, and carbon-fiber ceramics.[3] Competing materials are expected to continue challenging aluminum in the construction, container, and transportation markets.
- **New and innovative aluminum-based products will expand or create new uses for aluminum.** Over the next decade, opportunities for aluminum usage are expected to increase in the automotive, aerospace, container and packaging, building and construction, machinery and equipment, marine, infrastructure, and industrial products sectors, particularly as new specialty alloys, semi-fabricated product forms, composites, metal foams, and other products are developed to better meet user needs.

Automotive companies will increase their demand for efficient, lightweight materials. Significant growth in the use of lightweight and corrosion-resistant aluminum alloy components is anticipated in automotive and other transportation applications. Technologies that significantly lower the costs to automotive companies will trigger major increases in aluminum usage.

- **Light-weighting of vehicles reduces emissions**. Aluminum's higher strength-to-weight ratio gives it a performance advantage over steel in the automotive market. Efforts to produce aluminum more efficiently will further strengthen its attractiveness to automakers. Innovations may be needed to preserve its edge over other lightweight automotive materials, such as magnesium and glass- and carbon-fiber-reinforced plastics.
- **Aluminum components will excel in specific automotive applications.** Key growth areas are likely to include casting applications in engines (including diesel[4]) and power trains; niche, high-performance and high-value models; higher-volume models; and concept cars.[5] Growth of wrought products, especially wide sheet, will be greatly influenced by the success of new and more efficient production technologies. Aluminum spaceframe architecture is also likely to play a key role in enabling automakers to rapidly develop more efficient, safer, and lighter vehicles.

Aerospace and defense markets will seek high-performance solutions. Aluminum's unique strength-to-weight properties could play a key role in fighting terrorism through use in future weapons technologies and in fortifying commercial airline and other mass transit cockpits. Aluminum may also serve to protect control rooms and vulnerable components of other potential terrorist targets such as power, water, and telecommunications infrastructures. Lightweighting of defense transport, including amphibious vehicles, will continue in support of a highly mobile national force. Worldwide replacement of aging

aircraft, new defense aircraft, and the announced development of new Boeing and Airbus models will likely offer moderate long-term growth opportunities for aircraft-grade sheet, plate, and extruded products. Major aerospace projects, such as satellite launch vehicles and international space stations, will make greater use of advanced aluminum alloys and aluminum alloy metal-matrix composites.

Opportunities in packaging will expand with new technologies. Cans and other packaging will exploit new technologies to increase product functionality for the end user.

- **Beverage cans will offer a range of new functional features.** Among other capabilities, beverage cans will be able to be resealed, chill themselves, and indicate the temperature of their contents via color.[6]
- **Cylinders for gas under high-pressure could supply vehicle fuel cells.** If advanced propulsion systems for new vehicles require high-pressure gas, those systems will open a major market for strong, lightweight cylinders.

Mass transport (trains, buses, and marine transport) will be encouraged by governments to ease congestion on roadways. The public will demand safe, comfortable, and convenient passenger accommodations.

- **Safety will be a major issue.** Safety and related design features will drive material choice, although energy and repair issues will also count heavily.
- **Aluminum usage will continue to expand in marine environments**. The new generation of fast ferries and cruise ships will increasingly make use of aluminum's combination of strength, corrosion resistance, light weight, and end-of-life recyclability. New joining techniques will increase the use of available properties and reduce manufacturing and assembly costs. Other marine applications will include off-shore oil rigs and helicopter decks as well as combat and underwater vehicles.

The building and construction market will place increasing emphasis on sustainability. Education of builders, architects, designers, and regulatory bodies on aluminum's low-maintenance requirements, ease of re-use, and design flexibility will expand use of the material in curtain-walls, roofing, windows, and doors in both new construction and older building refurbishment. Sustainability will become a strong driver in this market.

Infrastructure renewal will require durable, cost-competitive materials. The transportation and energy infrastructures of North America are deteriorating with age. Revitalization and expansion are needed to meet the growing needs of the population.

- **Public decision-makers will seek to minimize expense and disruptions associated with major projects.** New materials and construction methods will be required to build or renew clean, safe, and efficient mass transit systems. Lightweight aluminum bridges can be lifted directly into place once the supports have been set. In an increasingly busy and mobile society, speedy project completion and lower maintenance will add value to aluminum materials.

- **New and upgraded electric transmission lines are needed**. Deregulation, regional transmission organizations, diversified energy sources, and new generation capacity will drive the demand for new, high-voltage transmission capacity. New and redesigned aluminum conductor technologies promise increased reliability for transmission systems.
- **Developing countries will need new infrastructure.** Development will require energy transmission networks, bridges, and transportation systems, all of which could be served by aluminum products. China's need for vast infrastructure development combined with its probable entry into the World Trade Organization is one example of several emerging opportunities for North American aluminum producers in developing regions.

Industrial products will take advantage of emerging aluminum-based materials. Industrial processes will seize upon the functional benefits of enhanced aluminum materials and composites to increase efficiency and decrease downtime and maintenance.

Aluminum Supply Chain

Historical segments of the aluminum supply chain will realign in response to distinct economic drivers and successful business models. The traditional structure of the industry– mining, refining, smelting, rolling, extrusion, casting– will change as upstream activities become more closely aligned with other mining and metal companies, while downstream activities become increasingly diversified and user-focused. Many smaller, specialized producers will continue to serve distinct customers with unique needs. At the same time, some vertically integrated producers (mining, refining, fabrication) are acquiring operations farther down the supply chain and integrating forward.

- **Customers will focus on functionality.** Successful downstream companies will increasingly respond to customer requirements for superior functionality. Demand will increase for multi-material solutions that capitalize on the unique properties of each material.
- **Direct producer/fabricators will serve specialized markets**. Regulations forcing more recycling of complex alloys and composites with plastic bonding will drive recyclers to develop capabilities to handle these material streams. Reliable sorting technologies will enable the correct matching of recycled aluminum materials to suitable production processes. This will minimize the need to add expensive alloying elements and further reduce energy use and emissions. Tailored recycling streams will encourage direct fabrication of specialized products for user industries.

Sustainability

Sustainability will become a mainstream issue. A corporate culture that emphasizes environmental stewardship, economic contribution, and social responsibility will emerge in the materials and process industries that operate throughout the world. Companies that

embrace sustainability principles will gain widespread acceptance by industrial and end-use customers. The aluminum industry will be ideally positioned to take advantage of this development.

- **Increased demand for "green."** Global development and population growth, climate change, and waste disposal issues will thrust environmental concerns to the forefront with consumers and industry around the world, driving the demand for "green" products and services. Advanced sensors, new materials, computer systems, energy systems, and new process technologies will help to eliminate waste and increase the recyclability of all products.
- **Environmental concerns will foster recognition of aluminum products as an "energy bank."** Increased recycling of aluminum and the energy benefits of aluminum products, coupled with increased energy concerns in North America, will lead to the recognition of aluminum products as an "energy bank."
- **Life-cycle analysis will assume increased importance**. Life-cycle performance will figure prominently in materials selection and product design, emphasizing product value over original cost. Aluminum's unique range of engineering capabilities, light weight, corrosion resistance, high thermal and electrical conductivity, and recyclability will increasingly serve as the basis for its use in new applications and product forms.

Aluminum Provides an Energy Bank

The electrical energy embedded in aluminum can be considered an "energy bank" because aluminum products can be endlessly remanufactured with only 5% of the energy and emissions originally required to produce the virgin product.

From a sustainability viewpoint, aluminum's high life-cycle value and recyclability make it the best option for retaining this "banked" energy and should be promoted vigorously. Recycling, in essence, is tapping into a convenient ***"urban mine"*** *of material that enables reuse while saving energy and reducing environmental impacts.*

Production

Production of recycled or secondary aluminum will play an increasingly significant role in the growth of the North American aluminum industry. New technologies will enhance the economics and efficiency of separation and recovery, boosting the industry's productivity and appeal to an increasingly ecology-minded public.

- **Recovery rates will increase with improved technologies.** Advanced technologies capable of sorting cast from wrought aluminum and separating alloys will boost recovery of containers, automobiles, and building materials and will extend recovery operations to additional products.
- **Imports of foreign scrap and primary aluminum may be needed**. Given the limited availability of domestic scrap and the long product life cycles of aluminum in construction and autos, North American producers may increase imports of foreign scrap and primary aluminum.

The need for primary aluminum will endure. The domestic supply of recycled aluminum will be insufficient to satisfy the growing need for aluminum, requiring new primary production or increased imports.

- **Changing dynamics in regional markets are affecting primary production centers.** Periods of volatility in electricity availability and cost could influence the geographic distribution of smelting operations. For the near to mid term, operations will continue to be attracted to locations that offer stable, affordable electricity, whether it is provided by low-sulfur-coal, advanced hydropower, or alternative power-generating options.
- **Technology advances could preserve primary production capacity.** Global economic factors will make it highly unlikely that any new Hall-Heroult smelters will be built in the United States. Continued operation of existing facilities will depend on the availability of reliable, competitively priced electricity and process optimization of existing reduction cells. Facility upgrades such as installation of advanced anodes and cathodes could play a key role in this optimization process. Revolutionary new technologies could re-stimulate domestic production capacity in North America.

Manufacturing

Technology-driven productivity gains will be a powerful source of growth. Application of new technologies to the manufacturing process will optimize processes as never before. Aluminum products of the future will offer better quality, greater reliability, and a consistently higher level of engineering performance.

- **Advances in casting and extrusion technologies will push aluminum ahead in automotive and other applications**. Advanced casting and extrusion technologies have attracted the interest of the research community. Developments in these areas, such as wide-sheet casting technology, new or enhanced extrusion capabilities, and other innovations, will increase aluminum use in automotive applications. Producers will enter agreements with automakers and other customer industries to directly supply customized aluminum components.
- **"Smart" fabrication systems will integrate power, sensors, and controls.** Such systems eventually will control the manufacturing process from beginning to end, continuously monitoring and adjusting process conditions and optimizing system efficiency.

Technology innovations will enable design and production of aluminum with special properties. Advances in manufacturing technologies will make it possible to build special capabilities into aluminum products, uniquely tailoring the material to meet specified needs. Examples include specific micro-structural textures in sheet products and unique profile cross-sections in extrusions.

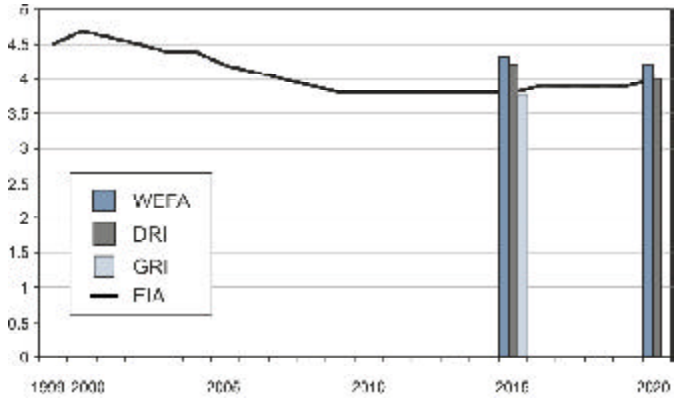
- **Nano-technology will create "super" materials**. Manufacturing of new materials at the molecular level will enable aluminum producers to create innovative, high-performance materials for highly specialized use in transportation, computers, energy, and communications. Nano-technology goods and services will be first introduced to industries in which users place a premium on new or improved performance, such as the aerospace industry.
- **Smart materials will be in demand for high-performance applications.** New materials for construction and other uses will be able to give warnings when they detect excessive stress. For instance, materials in bridges or office buildings could change color before conditions become unsafe. Automobile parts could give a similar warning when approaching the point of breakdown.

Energy

Periods of volatile electricity availability will challenge primary aluminum producers. Over the longer term, however, electricity supply should remain relatively stable.

- **Long-term industrial electricity prices will be reasonably stable.** As shown in Figure 7, electricity prices for the industrial sector are expected to decline 0.6 percent nationwide over the period 1999-2020, with some regional variation. They are projected to increase by 0.3 percent in the Northwest Power Pool and to fall by 0.5 percent in the East Central Area Reliability (ECAR) Council. On average, electricity prices will drop from 2001 until approximately 2008, hold steady until about 2015, and begin rising through 2020.[7]

Figure 7
Electricity Price Projections for Industry



- **Electricity prices will be volatile during restructuring.** Although restructuring is expected to lower long-term electricity prices, price volatility is likely over the next five to seven years. Electricity prices will increase in some parts of the country and decrease in others—a result of regional differences in demand, natural gas prices, transmission capacity, and other market conditions.[8]
- **New electrical power capacity will be built**. The United States will need to build between 1,300 and 1,900 new power plants by 2020. Currently, large amounts of new generating capacity are slated for installation around the country between 2001 and 2004. However, a geographic mismatch exists between where energy will be generated and needed. Environmental issues will exert a major impact on the availability and cost of electricity.
- **Risk-reduction strategies will be popular.** Some firms are already planning for a radically altered future by building their own power plants and switching their focus

from basic aluminum to higher-tech products.[9] Aluminum producers will need to work with end-users seeking long-term contracts and other financial instruments to reduce their exposure to the volatility of electricity supply.

- **Renewable resources will make a contribution.** Alternative distributed energy resources (wind, solar, and other) will offer new opportunities for electricity in the 2020 time frame.

Human Resources

Human resources will become increasingly critical to the aluminum industry.

- **The brightest college graduates will be in high demand**. As all industries adopt increasingly complex and sophisticated processing technologies, there will be keen competition for trained and qualified workers and for talented engineers and scientists trained in state-of-the-art technologies. Educational outreach programs to college and high school students, and even younger groups, will help attract highly qualified employees. A greater emphasis on education will be critical to maintain a sophisticated work force for an increasingly complex aluminum industry.
- **The work force will become increasingly diverse**. The U.S. Bureau of the Census projects that by 2020 the U.S. Hispanic population will have doubled its 1995 size to 53 million, becoming the second largest race/ethnic group overall and showing particularly strong numbers in prime work force age groups. Training, safety programs, manuals, and other corporate communications materials will accommodate both English- and Spanish-speaking employees, and corporate cultures will adjust to attract and retain this valuable segment of the work force population.

---

1 *International Energy Outlook 2001*, EIA, p. 107-108
2 ALFED, *Foresight Project* UK, November 2000, p.5
3 Ibid.
4 American Metals Market LLC, Focus: Metals in Motion, August 3, 2001 (AMM.com)
5 *Aluminum Today* Jan/Feb 2001, p. 31
6 ALFED, *Foresight Project* UK, November 2000, p. 8.
7 U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 2001. Similar drops in national industrial electricity prices over the next 20 years are predicted by Wharton Economic Forecasting Associates (WEFA), the Gas Research Institute (GRI), and Data Resources (DRI).
8 Study by the Energy Modeling Forum, School of Engineering, Stanford University, 1998.
9 BPA spokesman Ed Mosey, as reported in "The Power Hungry Get Powered Down," *The Electricity Forum* (www.electricityforum.com/news/apr01/closings.htm)

Vision of the Aluminum Industry

The growth of aluminum use over the past half century demonstrates the value that companies, consumers, and society place on materials that are lightweight, affordable, and recyclable. As the aluminum industry faces the next 20 years, it is well-positioned to lead all industries in providing sustainable, material-based solutions for new and enhanced products. Aluminum's unique attributes will play an essential role in meeting the heightened product expectations of an increasingly sophisticated and mobile society.

*By 2020, the North American aluminum industry will be universally recognized as a **world leader** in providing innovative, material-based **solutions** that build on aluminum's intrinsic **sustainability** and deliver **superior value** to users.*

Products and Markets

Whereas materials in today's markets compete based on a complex mix of prices, lead times, product attributes, and user perceptions of value, customer needs will dominate downstream aluminum activities of the future. For each application, manufacturers and users will work together to discover the optimal material-based solution—including composites and polymers that deliver the desired product performance. Since the global culture will value sustainability and mobility, aluminum will figure prominently in engineered solutions to many client needs. Used alone or in combination with other materials, aluminum will be a mainstay of many material solutions for the 21st century based on its beneficial attributes: light weight, high strength, corrosion resistance, thermal and electrical conductivity, and ease of fabrication and manufacturability.

Sustainability

Once produced, aluminum can be repeatedly and efficiently recycled without loss of quality. When corrosion-resistant aluminum products do reach the end of their often lengthy service life, they can be recycled into brand new aluminum products using only 5 percent of the energy that was required in their original production. With each round of recycling, 95 percent of the emissions are avoided as well. Advanced sorting and recycling technologies will enable closer matching of scrap to the secondary fabricator, which will expand existing recycling operations and capture additional streams to make aluminum the most recycled of all materials. This dramatic expansion of recycling will further strengthen the continuous circle of aluminum value.

Aluminum frequently saves energy and cuts emissions while in product phase as well. Currently, aluminum boosts fuel efficiency and cuts environmental emissions by substituting for heavier materials in automobiles and by reducing the weight of other products transported by vehicle. Under current conditions, each ton of aluminum (replacing two tons of heavier material) in a typical North American sedan will save an estimated 20 tons of carbon dioxide equivalents over the average life of the vehicle. Advances in production technology will enable a further increase in the use of aluminum in new, lighter, safer, and more fuel-efficient vehicles. These energy and emissions savings are substantial and will continue to yield increasing benefits relative to heavier materials in traditional use.

Advances in cell design are reducing the energy-intensity of primary production while the advent of inert anodes and new cathode designs have the potential to cut emissions of greenhouse gases dramatically. By 2020, far more efficient smelting technology will be replacing the Hall-Heroult process. By 2050, the lowered energy use and emissions levels associated with primary production will be entirely offset on a life-cycle basis by the energy and emissions savings achieved through recycling and vehicle lightweighting (relative to traditional materials).

Energy and Resources

The energy-intensive smelting process converts electrical energy into a usable and stable material: in essence, aluminum is an "energy bank." Aluminum's amazing recyclability ensures that deposits made to this bank will preserve value. While more energy-efficient smelting technologies are being developed, the energy put into aluminum production remains intact in the recycling loop.

The industry will cut smelting energy use to 11 kWh/kg or less by 2020 and achieve additional energy targets set by existing and future industry roadmaps. Technology advances in cell design and materials such as non-consumable anodes will conserve resources, reduce emissions, and eliminate disposal issues. While technology development is underway to cut energy use in primary production, aluminum will continue to reduce fuel use by an average of 5-8 percent for every 10-percent reduction in the weight of today's vehicles.

By 2050, the industry will reduce its energy consumption until it eliminates any energy disadvantage in competing with other materials on a full life-cycle basis. At that point, far more efficient smelting technology will have replaced the Hall-Heroult process.

Technology

By employing some of the best talent in all of manufacturing, the aluminum industry will pioneer new technologies for enhancing aluminum's unique properties to meet customer needs. Material engineering will require advanced understanding of microstructures and the creation of extensive technical databases for predicting the properties that can be achieved in various alloys and composites. The industry will actively build such databases through corporate efforts or through public-private R&D partnerships in conjunction with universities and national laboratories.

In addition to its own technology developments, the aluminum industry will look to other process industries for solutions to some of its key technical issues. Advancements in modeling techniques, sophisticated control systems, and materials treatment and handling may be tailored to improve aluminum processing and product design. State-of-the-art design techniques and processing technologies will help the aluminum industry stay ahead of the curve with regard to emerging technical requirements and markets.

Education and Outreach

Much of aluminum's success in the global markets of tomorrow will depend on the industry's ability to effectively communicate aluminum's life-cycle value. It must clearly imprint aluminum as "sustainable" in the minds of investors, users, employees, politicians, regulators, and other stakeholders. Toward this end, the industry will launch an ambitious communications campaign that reaches out to schools (K-12), broadcast media, associations, non-government organizations, and other groups. To support the effective communication of consistent messages, the industry may maintain authoritative and easily accessible information products and databases and generate engaging website tutorials.

Human Capital

The ambitious technical progress envisioned for the aluminum industry will require a highly educated and skilled work force. Educational initiatives will stimulate early interest by talented graduates, and their achievements will help build the industry's reputation as a clean, innovative, and high-tech industry. To build a pool of qualified candidates, the industry will join with government, professional associations, universities, and others to launch a variety of

Aluminum Industry Goals

Products and Markets

- Deliver superior value in engineered material solutions tailored to customer needs.

Sustainability

- Exceed the recycling rate of all other materials and establish the industry as a leader in sustainability.
- Make a positive net impact on the environment over the life cycle of aluminum products.
- Produce zero net emissions of greenhouse gases on a life-cycle basis.

Energy and Resources

- Meet or exceed a target of 11 kWh/kg for smelting and achieve additional energy targets established by industry roadmaps.
- Generate a net energy advantage over the life cycle of aluminum products.

Technology

- Achieve universal recognition as a technology leader applying cutting-edge technology to create innovative products, improve the environment, and contribute to economic growth.
- Aggressively seek out technical innovations in other industries and apply them to improve aluminum processing and products.

Education and Outreach

- Achieve broad public understanding and acceptance of the life-cycle value of aluminum, its key role in technology innovation, and its essential contributions to modern lifestyles.
- Fortify academic programs to develop and attract top science, engineering, and business graduates.

Human Capital

- Employ one of the most highly skilled and best educated work forces in the process industries—one that reflects the population's cultural and linguistic diversity.
- Exceed the health and safety records of all similar processing industries.

educational initiatives. Examples of such initiatives might include curriculum development, mentoring, and grant programs to encourage studies in advanced metallurgy and related fields. The industry will similarly reach out to skilled workers of diverse cultural backgrounds to engage their interest in working with this progressive industry. The industry will aggressively facilitate the worldwide adoption of environmental, safety, and health best practices, building the best safety record of any processing industry.

Implementation Strategy

Effective implementation of this vision will dramatically improve the global competitiveness of the U.S. aluminum industry, reduce its environmental footprint, and firmly establish aluminum as an ideal material for 21st-century applications.

The main elements of the industry's strategy for achieving its vision and goals are as follows:

- **Roadmaps**: Develop technology roadmaps that identify specific technology issues and barriers and set priorities to achieve industry goals. Use roadmaps to attract and influence technical, intellectual, and financial resources to carry out the needed efforts.
- **Collaborative Partnerships**: Leverage resources and capabilities among aluminum producers, customer and supplier groups, equipment manufacturers, universities, national laboratories, government, and other stakeholders to accomplish R&D that will yield broad benefits to the entire industry and to the nation.
- **Corporate R&D**: Recognize that individual companies will continue to play an important role in pursuing corporate R&D interests and in commercializing new technologies. Corporate R&D is carried out independently or in conjunction with other entities, including members of the supplier and customer industries, in a manner consistent with all applicable antitrust laws.
- **Communications and Outreach**: Organize efforts among aluminum producers and other key stakeholders (customers, suppliers, related trade or industry groups, equipment manufacturers, universities, non-government entities, and environmental organizations, etc.) to promote public and regulatory policies that will yield broad benefits to the entire

The Aluminum Vision is intended to stimulate a wide variety of R&D activities to accelerate technology development throughout the industry. A host of R&D approaches are needed to provide a rich and diverse portfolio to meet tomorrow's challenges and opportunities. These approaches may include:

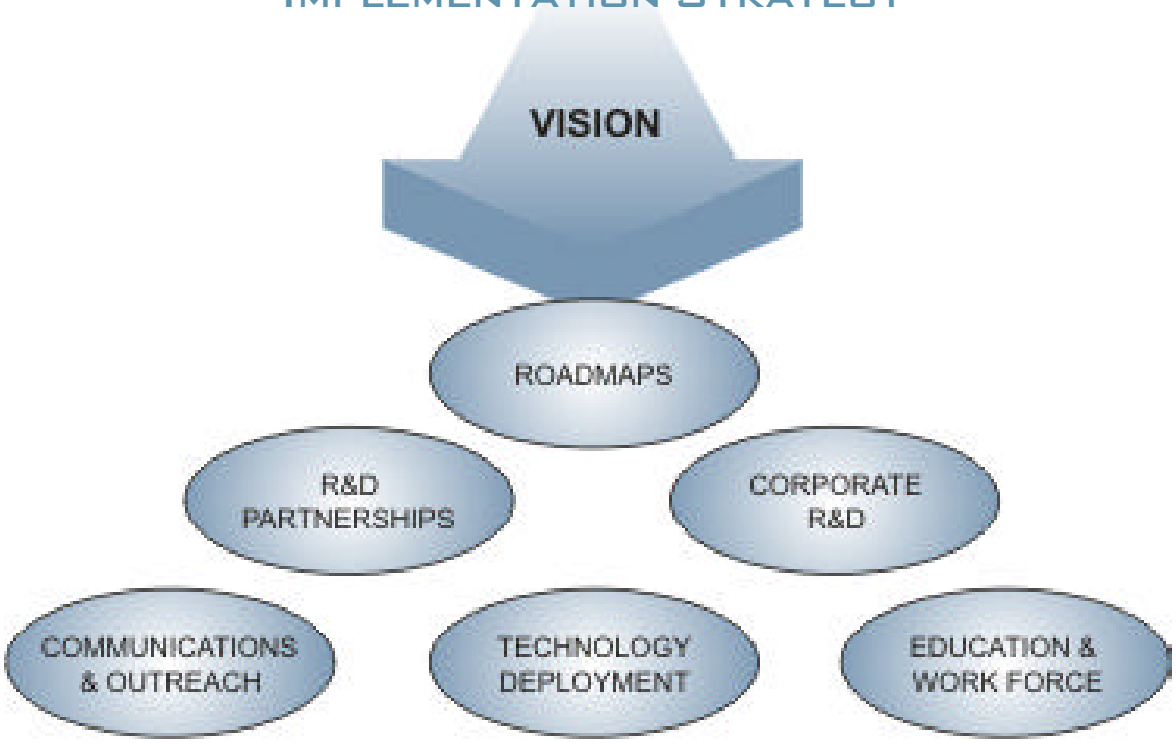
- *In-house corporate research*
- *Collaborative R&D with universities, laboratories, and research consortia*
- *Partnerships with manufacturers, suppliers, and customers*
- *International research coordination*
- *Broad public-private partnerships*

Some of these efforts involve the participation of aluminum companies in cooperative research projects, consistent with applicable antitrust laws and with the free and open competition that is a hallmark of the aluminum industry. All of these approaches make an important contribution to the aluminum industry technology portfolio.

industry. Launch public information campaigns to effectively communicate aluminum's unique life-cycle and sustainability messages to a broad audience.

- **Technology Deployment**: Promote rapid deployment of efficient technologies throughout the industry.
- **Education and Work Force**: Recognizing that technological solutions do not occur in isolation, support major educational initiatives that address:
  - Student outreach and education to prepare and attract top graduates
  - Multi-lingual training materials and outreach for the work force of tomorrow

Implementation Strategy



Achievements 1996-2001

The implementation strategy builds upon the successes and achievements of the past five years, as summarized below:

- In 1996, The Aluminum Association published the aluminum industry's initial **vision** statement, *Partnerships for the Future*, which outlined broad goals for the next 20 years. This living document is meant to be updated periodically to reflect important changes in the industry and its operating environment.

- Later the same year, on behalf of the U.S. aluminum industry, The Aluminum Association signed a **compact** with the U.S. Department of Energy (DOE) to work cooperatively toward shared energy and environmental goals.
- In 1997, The Aluminum Association released its *Aluminum Industry Technology Roadmap*, a detailed R&D agenda with priorities and milestones for achieving the Vision goals. The **roadmap** attracted worldwide interest and was translated into several languages.
- The Aluminum Association, in conjunction with other industry organizations, subsequently prepared five, more **sharply focused roadmaps** that address inert anode technology, automotive applications, bauxite refining, applications of advanced ceramics, and alumina production.
- By articulating the industry's R&D priorities, these roadmaps **stimulated public and private R&D** to focus on industry's toughest technological challenges. Producers, suppliers, universities, national laboratories, government, and others undertook a wide variety of efforts. Large, collaborative partnerships shared the costs and risks of long-term R&D projects that offer broad benefits to the industry and the nation.
- Since 1996, the roadmaps have generated in excess of **$100 million worth of cost-shared research projects** involving over 75 aluminum companies, suppliers, universities, and national laboratories.

Partnership Documents

- *Partnerships for the Future* (Vision), 1996
- *Aluminum Industry Technology Roadmap*, 1997
- *Inert Anode Roadmap*, 1998
- *Aluminum Industry Technology Roadmap for the Automotive Market*, 1999
- *Technology Roadmap for Bauxite Residue Treatment and Utilization*, 2000
- *Applications for Advanced Ceramics in Aluminum Production*, 2001
- *Alumina Technology Roadmap*, 2001

Partnerships and Progress

The original roadmap set the framework for the formation of a variety of collaborative technology efforts that effectively investigated promising, complex technology options that would have been too long-term or high-risk for many individual firms to undertake. By combining the talents, expertise, and resources of diverse organizations, these efforts substantially accelerated technology development, moving several concepts to the stage at which individual companies were willing to take over further development.

This 2001 update of the industry vision is expected to establish the framework for an update of the industry's 1997 technology roadmap. The revised vision goals and progress in technology development are likely to generate new milestones or performance targets and

adjustments to R&D priorities. In addition, the scope of the roadmap is expected to expand to include non-technical areas—particularly educational activities that will provide far-reaching benefit to the industry as a whole.

Partnerships offer a promising means to further leverage resources and accelerate future R&D and non-technical progress. As shown in the table, a variety of organizations at the federal, regional, and international levels have participated in R&D-related activities to date.

Examples of Joint Efforts

Organization	Function	Activities
Regional		
Secat	An initiative to retain and expand the aluminum industries in Kentucky and neighboring states	Technical research and educational services
National		
Automotive Aluminum Alliance	A recent alliance between The Aluminum Association and Daimler-Chrysler, Ford, and General Motors	Projects to minimize the environmental footprint of aluminum throughout its life cycle: reducing the cost of using aluminum sheet in automobiles, separation by alloy family, hydroforming and tailor-welded blanks, F019 wastewater sludge, and vehicle repair
U.S. Department of Energy's Office of Industrial Technologies, Aluminum Industry of the Future.	Fosters collaborative R&D efforts among industry, government, universities, suppliers, and other stakeholders	R&D projects address the industry's top pre-competitive needs and also help meet national goals for energy and the environment. Projects range from advanced cell technology to enhanced combustion technologies and improved treatment of molten metal. All focus on improving the energy efficiency and environmental performance of aluminum production processes.
International		
The International Aluminium Institute	A global forum with 22 member companies in 23 countries	Dedicated to the development and wider use of aluminum as a competitive and uniquely valuable material
Aluminum for Future Generations	A three-year campaign funded and promoted by the major aluminum companies of Europe	Educating legislators, decision-makers, non-government organizations, and economic research centers about sustainability issues
AMIRA International	The Australian Mineral Industries Research Association organized an informal joint effort by industry groups including 10 firms from 4 continents, academia, and U.S. government	Workshop to develop the Alumina Roadmap, May 2001

Participants

Aluminum Producers and Manufacturers

Aluminum companies from all sectors of the industry provide essential input to the vision and roadmapping efforts. These seminal documents derive their power to attract public and private R&D resources entirely from the broad participation and approbation of aluminum producers and manufacturers.

Aluminum companies that participate in R&D partnership activities get more research out of their available resources. By combining resources, aluminum companies are able to tackle projects that would otherwise be too large, complex, expensive, or time-consuming to undertake on their own. The quantity, quality, efficiency, and speed of research are markedly increased.

Aluminum companies bring to their R&D efforts a unique, firsthand knowledge of realistic operating conditions and constraints. Producers' specialized knowledge and ability to supply real materials and test sites help ensure that technologies will perform reliably in plant use.

Suppliers

Many of the real technology advances achieved in aluminum processing over the past five years owe much to the involvement of businesses that supply equipment and products to the industry. These businesses that rely on aluminum companies as major customers have every incentive to participate in developing the needed technologies. Many are heavily involved in R&D and welcome the opportunity to work closely with their customers and other players. Based on this strong track record, entities involved in R&D partnerships should consider the potential value added by including equipment suppliers on the team.

Customers

Aluminum's customer industries are perhaps the most important stakeholders in advanced aluminum processing and technology development. They represent the decision-makers who will apply functionality criteria for future products and select from among various material solutions. Their valuable insight into anticipated material requirements can help the aluminum industry provide optimal solutions to future material needs. Customer industries have actively participated in roadmap development and many R&D partnerships. Indeed, the *Aluminum Industry Roadmap for the Automotive Market* was produced in close cooperation with the U.S. Automotive Materials Partnership. Customer input on any R&D team helps to ensure that the results will add real value to aluminum products.

Government

While the industry is uniquely suited to determine its own priorities for technology development, government has an important role to play in facilitating the planning process, stimulating investment in priority R&D, and making newly developed technologies more rapidly and cost-effectively available for broad use throughout the industry. Government

entities, such as the U.S. Department of Energy's Office of Industrial Technologies (OIT), serve a valuable function by providing a neutral forum and supporting R&D development and deployment efforts.

OIT and its Industries of the Future strategy were the catalysts that initially brought the industry together, then encouraged and facilitated a substantive discussion on its long-term vision for the future. OIT also helped sponsor the workshop for outlining the original technology roadmap to achieve the vision. This roadmapping effort gave the industry the opportunity to identify areas in which aluminum companies, in a manner consistent with applicable antitrust laws, could share resources to achieve common energy and environmental goals and suggest how the Department of Energy's resources could be most effectively and efficiently applied.

The Aluminum Industry of the Future partnership has created a valuable forum for engaging all stakeholders in a process that is generating broad energy and environmental benefits for the industry and the nation. The inclusive nature of the partnership has generated new opportunities for the industry to interact with its suppliers and customers, greatly enhancing information exchange, understanding of technology challenges, and opportunities for technology solutions.

The process has stimulated numerous examples of cross-industry collaboration that are beneficial to the aluminum industry. The workshop with the United States Advanced Ceramics Association that led to the publication of *Applications for Advanced Ceramics in Aluminum Production* is just one example. Similar events and informal consortia have stimulated valuable communications with the automotive, metal casting, welding, and wind turbine industries. OIT's enabling programs have also helped to focus the attention of the sensors and controls and advanced materials research communities on the needs of aluminum producers and fabricators.

Government agencies also play a pivotal role in providing the extra financial support necessary to get many R&D projects rolling. Industrial products and processing technologies have become extremely sophisticated and complex, so that R&D often requires the collaborative efforts of experts in diverse fields of specialization. Such diverse R&D teams can be difficult to assemble, and few private firms are willing to make such a major investment in long-term, high-risk R&D. Government, in contrast, can provide cost-shared support for high-risk, high-payoff research in pre-competitive areas that generate real advances in productivity and energy efficiency. OIT is a key player in this area. Other government offices also control substantial budgets that could be further leveraged to support aluminum R&D and promote broad implementation of the resulting technologies. Such offices include DOE's Office of Energy Research, the National Science Foundation, the National Institute of Standards and Technology, the Navy's Manufacturing Technology Division (ManTech), Army TARDAC, the Office of Naval Research, and the Air Force Office of Scientific Research.

Building the Future

While many of the industry's goals build on the beneficial properties of aluminum, the attainment of many of the most challenging technological goals will require large, costly, multi-disciplinary, and carefully orchestrated collaborative R&D efforts. Since the U.S. aluminum industry's first roadmap was published in 1997, aluminum producers, research laboratories, and others have proceeded to undertake collaborative R&D projects and accelerate progress toward long-term goals. Based on the success of these efforts, they will continue to be a cornerstone of the industry's pursuit of R&D efforts that yield broad benefits to the entire industry.

In summary, the vision implementation effort should take full advantage of lessons learned from experience over the past five years:

- Encourage collaborative R&D efforts with suppliers, vendors, users, and others
- Examine any existing barriers to such efforts
- Actively seek new vehicles to facilitate such efforts
- Further leverage R&D funds through partnerships with additional Federal agencies

Process and Acknowledgments

In 2001, The Aluminum Association responded to changes in the aluminum industry, its supporting infrastructure, and operating environment by calling for a reexamination and update of the industry's 1996 vision document. To guide the updating process, the Association formed the 2001 Aluminum Vision Steering Committee, chaired by Rick Lawrence of Alcan. The Committee actively sought input for the vision update from companies and associations throughout the industry.

The Vision Steering Committee designed an electronic survey as the central vehicle for collecting input for the vision. After review by legal counsel, the surveys were distributed by e-mail to all 52 members of The Aluminum Association and to other leading aluminum companies and associations in North America and around the globe. In all, 67 organizations received the survey. The completed surveys were collated into two groups: North American and international. On most issues, the responses from North America indicated a clear consensus. For the most part, the international responses echoed those sentiments. Many respondents took the time to share their perspectives on current trends and made important suggestions for industry goals for the future. Their thoughts on the trends, issues, and goals provided valuable insight on the challenges and opportunities facing the industry in the decades ahead.

Vision Steering Committee

Rick Lawrence (Chair), Alcan Inc.
David Williams, Alcoa Inc.
Subodh Das, Secat, Inc.
Ray Peterson, IMCO Recycling
Steve Larkin, Mike Skillingberg, and Bob Strieter, The Aluminum Association, Inc.
John Green, Consultant

As a group, the Steering Committee evaluated the collated responses and shaped them into visionary goals for the industry. Members of the Committee also approved the structure for the document, supplied detailed data on current and projected trends, performed in-depth analyses of key issues, and carefully reviewed and edited successive drafts of each section.

Companies and associations that have contributed in some capacity to the development of this document represent a majority of the North American aluminum industry.

Contributors include:

Alcan Inc.
Alcoa Inc.
The Aluminum Association Inc.
Aluminum Association of Canada
Aluminum Federation of South Africa
Alumitech
American Foundry Society
European Aluminum Association
Golden Northwest Aluminum, Inc.
Gulf Aluminum Rolling Mill Co.
IMCO Recycling, Inc.
Indalex Aluminum Solutions
Kaiser Aluminum
KB Alloys, Inc.
Milward Alloys, Inc.
Nichols Aluminum
Secat, Inc.
Smelter Service Corporation
Weber Metals

The Aluminum Association gratefully acknowledges the assistance provided by the U.S. Department of Energy in facilitating the aluminum vision process and by Energetics, Inc. in writing, editing, and preparing this document.

Did you know?

- The U.S. aluminum industry provides 144,300 jobs paying an average of $36,100 per year, and shipped $37.9 billion in products in 1999. — *The Aluminum Association, Inc.*
- Using recycled aluminum instead of raw materials reduces air pollution by 95%, water pollution by 97%, and energy use by about 95%. — *DHEC Office of Solid Waste Reduction & Recycling*
- Used aluminum cans are recycled and returned to store shelves as new cans in as few as 60 days. — *Cancentral.com*
- The U.S. aluminum industry supplies material enabling the production of 100 billion cans annually or about one can per person per day. — *Subodh Das, Secat, Inc.*
- Each pound of aluminum replacing two pounds of steel can save a net of 20 pounds of CO_2 equivalents over the typical lifetime of a vehicle. — *Auto Aluminum Alliance*
- A 6-8% fuel savings can be realized for every 10% weight reduction by substituting aluminum for heavier materials. — *Auto Aluminum Alliance*

The Aluminum Association
Incorporated
900 19th St., N.W., Washington, D.C. 20006
www.aluminum.org