This lecture series began in 1971 focused on the links between materials, energy, and the environment. The issue of sustainability had emerged, but only as an exploration of the possibility of materials depletion in the face of predicted population growth. Today, sustainability implies a global economic and social system that both satisfies human needs and does not despoil the earth. What has been our role in this increasingly important arena of human concern and what should it be?

Our report card is impressive. Improvements in processing, in materials substitution, in design to minimize materials usage, and in recycling of metals and polymers have all been remarkable. However, we are faced with twin dreadnoughts of change in the next decades: technological ascendency of developing nations and rising world population. Add to these the need to reduce the effluence of greenhouse gases and we must anticipate formidable technological upheaval throughout the materials cycle.

Our professional societies need to step forward and play larger and significantly more visible roles in this arena. Working individually and in concert with others, the societies must broadcast our achievements, identify future areas for activity, support industrial road-mapping efforts, and join with all who will participate in clarifying the flow of materials throughout their life cycles.

I. INTRODUCTION

GOOD morning. I’m honored to have been asked to speak to you today, and humbled when I realize that my name has been added to the list of distinguished lecturers, so many of whom I have known and respected throughout my career.

This lecture series began in 1971 with a presentation by Dr. Lyle H. Schwartz was Director of the Materials Science and Engineering Laboratory (MSEL) of the National Institute of Standards and Technology (NIST) from 1984–1997, when he retired. He was responsible for NIST’s materials research, including more than 360 scientists, engineers, technicians, and support personnel, and an annual budget of approximately $65 million. The MSEL is responsible for providing the private sector and government agencies with data, measurement methods, standard reference materials, and new scientific concepts, which are fundamental to the development of high performance materials and to advances in materials processing. The programs support the measurement and standards infrastructure required for the safe, efficient, and economical use of materials to meet national needs.

As chair of the NIST Laboratory Council, Schwartz led his colleagues, the directors of the other technical laboratories at NIST, in the development of a strategic plan for the laboratories, and in the organization and management of an extensive effort in technology transfer and government and private sector partnerships. He chaired the National Science and Technology Council’s Subcommittee on Materials Technology and chaired its predecessor, COMAT. In both committees, materials programs are coordinated across the federal government and with the private sector. Under COMAT, Schwartz was responsible for the development of the Advanced Materials and Processing Program, bringing visibility and increased focus to the $2 billion federal R&D efforts in materials. Schwartz is active in professional societies and is a recent past member of the Board of Trustees and fellow of ASM International and a past councillor of the Materials Research Society. He served on advisory committees for several university materials departments and research centers, and is a past chair of the Board of Governors of the Institute of Mechanics and Materials, University of California–San Diego. He received the 1993 Leadership Award of the Federation of Materials Societies, and the 1994 Leadership Award of The Minerals, Metals and Materials Society. Schwartz is a member of the National Academy of Engineering.
Harvey Brooks[1] who focused on the links between materials, energy, and the environment. At that time, the issue of sustainability had emerged, but appeared first as an exploration of the possibility of materials depletion in the face of predicted population growth. In this lecture today, I intend to return to the theme of sustainability, a theme made more relevant by the current debate about greenhouse gases and the global climate, but one which is central to the materials industries and the users of their products. I cannot hope to do justice to such a broad topic in this brief address, but will try to draw several themes together to establish the basis for several recommendations. There are roles to be played by industry, by academia, by government, and by each of us individually and collectively through our societies. While I will make passing remarks about the other arenas, I will aim my recommendations at the government and the professional societies, the arenas about which I can speak with the most personal and current knowledge.

Our economy and that of the other nations in the world depends on materials to an extent that most nontechnical persons do not realize. Materials are, after all, “the stuff that things are made of.” At issue today is whether we can long maintain the current level of use of this “stuff.” If, as expected, both economic activity and population will grow significantly worldwide in the next half-century, the current per capita use of materials will certainly be unsustainable. Indeed, the OECD recently adopted a long-range goal that industrial countries should decrease their materials intensities by a factor of 10 over the next 4 decades. That would be equivalent to using only 66 pounds of materials per $100 GDP, compared to the present value of approximately 660 pounds per $100 GDP. If achievable at all, much of these savings would come from the construction and mining industries, the largest users of materials in tonnage, but opportunities for more efficient use of materials would need to be found in every aspect of our industrial and service economy. Are such efficiencies achievable, and if so, can they be obtained through the application of existing technologies or must new technology be developed? We have no comprehensive answer to such questions, yet we would hope that governments would turn to members of the materials community for answers as they make public policy on issues relating to sustainable development.

Today we find ourselves more sensitive to desires to achieve a sustainable world economic and social system, which both satisfies human needs and does not despoil the earth. Brown air in the capitals of many of the world’s countries, holes in the ozone layer, and increases in greenhouse gases with their attendant climatic consequences have made some of the negative impacts of current technology apparent to all. The centrality of materials usage to this subject should make the achievement of sustainability our issue, but environmental issues have not always been visible on our lists as we identified our priorities for future attention. Indeed, it is more common today to hear the mechanical and electrical engineering communities discussing dematerialization and alternate materials technologies with ecologists and economists. What has been our role in this increasingly important arena of human concern and what should it be?

Think back to the times in which this series of lectures originated. Those were the days of awakening consciousness: the first earth day on April 22, 1970, the development of “green” political parties and action organizations, the beginning of a period of rapidly escalating regulation, and the inception of a heightened awareness of the links between materials, energy, the environment, and rising population. Two landmark studies captured the thinking of that era about the role of materials. In 1973, the report of the Congressionally mandated National Commission on Materials Policy appeared. Entitled “Materials Needs and the Environment Today and Tomorrow,”[2] this document contained a detailed discussion of the materials cycle and many recommendations for government action. Shortly thereafter, a major NRC study was published. This monumental effort was a product of the ad hoc committee on the study of materials (COSMAT), chaired by Morris Cohen. Titled “Materials and Man’s Needs,” this text[3] set the stage for how we thought about materials science and engineering for the next 20 years, clarified our concern with structure-property relationships, and graphically focused our attention on the whole materials cycle. Indeed, it was from the COSMAT study that we derived the representation of the materials cycle, (Figure 1), which still defines the scope of our field. These two documents, the first emphasizing policy and the second exploring technical issues, education, and R&D, represented high water marks for focus of attention by the materials community on the links between what we do and the consequences to the environment.

While many of the specific recommendations in these volumes are a bit dated, the general principles still apply and are worth repeating here. The three summary directives for policy makers were as follows:[4]

“Strike a balance between the ‘need to produce goods’ and the ‘need to protect the environment’ by modifying the materials system so that all resources, including environmental, are all paid for by users.”

“Strive for an equilibrium between the supply of materials and the demand for their use by increasing primary production and by conserving materials through accelerated waste recycling and greater efficiency-of-use of materials.”

“Manage materials policy more effectively by recognizing the complex interrelationships of the materials-energy-environment system so that laws, executive orders, and administrative practices reinforce policy and not contradict it.”

While significant progress since the early 1970s may be found on all three fronts, these principles could well be taken today as guidance for our continued efforts in both public and private arenas.

As the decade of the 1970s passed, other lecturers in this series returned to environmental issues. James Boyd devoted his 1973 lecture[5] to resource limitation in the context of what he termed the resource trichotomy: materials, energy, and the environment. Michael Tennebaum[6] included references to the environment in his 1975 lecture, describing what he saw as lack of balance in regulation efforts with too much focus on the near term. Herbert Kellogg[7] in 1978 returned to the subject of conservation and anticipated the current term “dematerialization” to describe the more efficient use of materials. However, with the exception of several passing allusions to the need to be environmentally sensitive in everything we do, later speakers in this series have not devoted any serious consideration to the subject.

The visible evidence of our apparent disinterest in the