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# Energy Foundations for Sustainable Development

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## EXTENDED ABSTRACT

Large quantities of low-cost energy in the form of fuels and electricity are essential for the functioning of modern industrial economies. Worldwide, more than three-quarters of our energy needs are obtained from non-renewable reserves of coal, oil, gas, and uranium. Furthermore, the global energy appetite is growing year by year as populations expand and industrial output increases. The unavoidable outcome of our present path is the depletion of all non-renewable energy resources -- some sooner than others, but all eventually.

Further exacerbating the energy picture is the mounting cost of mitigating the adverse environmental and health impacts of energy use. Problems ranging from acid rain and radioactive waste storage to the potential for widespread environmental disaster that could result from the buildup of greenhouse gases in the atmosphere have made it inescapably clear that the earth's capacity to absorb the waste products of energy use without serious consequences is being severely strained. Increasing energy use in the future must inevitably be accompanied by further cost escalations to forestall these consequences. Thus, potential supply shortages and mounting costs for the energy component of our industrial enterprise will increasingly undermine our ability to sustain global economic development. To offset these persistent negatives, strong positive actions that shore up the energy foundations of our economy are called for. The purpose of this presentation is to focus attention on two such proactive steps which, though insufficient to the task by themselves, are nevertheless crucial to any effective plan for heading off the recessionary tendencies of our growing energy supply and cost dilemma.

The first of these essential steps is to develop a much better arrangement than we currently have for including *all* costs for the adverse health and environmental impacts of industrial production in the price paid by consumers for fuels, electricity, and manufactured goods. Current practice includes only some of these costs, leading to situations that are sub-optimal, inequitable, and short-sighted and thus to strongly polarized positions - "owls vs jobs" - that fuel the intense public debate on environmental and health issues associated with incinerators, waste dump sites, power plants, steel mills, chemical plants, semiconductor manufacturing, and a wide range of other manufacturing operations. In contrast, as more of the real costs are passed on to the consumer, the environmental and health risks currently being borne by others because of proximity to manufacturing and power production facilities will be reduced. An additional and highly desirable consequence of this approach is that choices regarding energy supplies and fuels can be made on the basis of the full cost of production, rather than with the benefit of being "subsidized" by those currently bearing uncompensated risks. This concept is widely regarded as essential for long-term sustainable development, but its implementation has been largely unaccomplished because of the considerable difficulty of evaluating health and environmental risks and of determining the appropriate costs to be transferred to consumers. However, help may be on the way. There is currently under way a considerable effort to develop comprehensive life-cycle analytical methods for estimating these costs with sufficient reliability to be useful. It is significant that the effort to develop these methods is being led by some of the major industrial corporations, who have grown weary of being caught unprepared for the continued tightening of environmental requirements and unanticipated cost increases for energy and raw materials. The effort to develop and implement these life-cycle analytical methods should be strongly encouraged and supported and, as these methods become well established, they should be incorporated into the economic process for setting prices of electricity, fuels, and manufactured goods.

The second essential action is to expand our R&D effort to develop new manufacturing processes and new materials and products that meet our needs for power, fuels and consumer goods at lower cost, greater efficiency, and with reduced environmental cost. The decisions as to where to focus the R&D effort should be made using the comprehensive life-cycle cost methods described above. Examples of this approach, drawn from recent

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Argonne-industry cooperative R&D projects, will be described. These cover a wide range of industrial areas including steel, aluminum, brass/bronze, and automobile manufacturing; petroleum refining; plastics; and petrochemicals manufacture. The examples illustrate how the economics of manufacturing processes can be improved in a number of ways by a) reducing energy and raw materials requirements, b) reducing the quantities of waste produced, c) converting process waste to useful feed materials or products, and d) converting post-consumer trash to recyclable materials or products.

Finally, the production and use of electricity and fuels from primary energy resources (oil, gas, coal, uranium, and renewables) will be discussed against the backdrop of life-cycle analysis of the costs of production. Particular attention is given to energy supply and waste products of conversion and use for each primary resource, since these are the primary determinants of the relative cost and public acceptance for the various energy supply alternatives. Oil is the most versatile energy resource, supplying both power and transportation fuels, but is headed for extinction in the near future. Gas reserves are more plentiful, it is the cleanest fossil resource, and it contributes least to greenhouse gas buildup. However, less expensive processes are needed for conversion to liquid fuels for transportation uses and to chemical feedstocks if it is to replace oil. Coal is a wild card. With enough reserves for centuries it clearly will continue to be the mainstay of power generating capacity in many areas. However, the environmental problems from coal use as a fuel are very expensive to handle, even with today's emission control requirements. If these requirements tighten and $CO_2$ emissions limits are mandated in order to control greenhouse gas levels, the costs of coal for fuel uses could rise significantly. One way to pay for these increasing costs is to develop other products from coal that have greater value, such as new high-performance polymers. Some ideas along these lines will be discussed.

Renewables are the Cinderella energy resource. They are environmentally cleaner than all other sources of energy and they are available in inexhaustible quantities. However, the costs of renewable energy, whether for electric power from photovoltaics or fuels from biomass, are generally too high to be competitive with conventional fossil and nuclear energy. Many argue that the real cost difference is much less than current costs suggest, because of hidden subsidies for fossil fuels and nuclear power, but still much remains to be done to bring down the costs of fuels and power from renewables. Approaches for developing highly efficient processes for converting solar energy directly to chemicals for use as fuels and high-value products will be discussed.

The presentation will conclude with a summary that attempts to sort out the advantages and disadvantages of the various alternative routes to secure and stable long-term energy supplies needed to sustain our global economy for the next century and beyond.


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