ADDRESSES AND CONTRIBUTED PAPERS

THE ENERGY FUTURE FOR INDIANA

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Introduction

There are several reasons for selecting this topic for the address to the Indiana Academy of Science in 1981. Most energy studies are federal and international in nature. I believe that it is important to take a look at the regional and local aspects of energy futures. The energy picture, although still highly volatile, has stabilized somewhat in the last six years so that a prediction of the future can be related now to certain assumptions and objectives with a degree of clarity that might not have been possible in the mid 70s. Furthermore, there is a great deal in the way of self-fulfilling prophecy in the prediction of futures. I believe that various approaches to energy in the state will be affected by the predictions that are made. I am proposing a general approach which I believe is not only possible, but would be good for the state to undertake in terms of its economic development and its employment situation. Therefore, the possibility of this and many other presentations having some effect on the outcome is one reason for undertaking this topic.

Hypotheses for Prediction

There are four major hypotheses behind these predictions for Indiana. First, the interdependence in energy-related affairs will not go away. For instance, for many years in the 1960s, there was an assumption on the part of automobile companies, based on input from energy companies, that stable oil availability and pricing would continue well into the end of the 20th century as it had been in the post Second World War time period. It was this assumption, not mistakes in engineering, which caused problems with respect to the marketing and, therefore, the production of cars that today are not as competitive in world markets as they might be. Another clear case of interdependence is our dependence upon a continuing relatively peaceful situation in the Middle East—peaceful enough, that is, for the supplies of oil from that region to the United States to continue. Thus, the Department of Defense actions, insofar as they maintain peace in the Middle East, are more important to the future of energy than those of the Department of Energy.

Another demonstration of interdependence is the question of the relationship between energy and inflation. The effects of energy supply on inflation lead to political decisions. The best example is the long term suppression of natural gas prices because of control by the government; leading to the reduction in new supplies of natural gas and its relative scarcity. Although arguments can be presented on both sides, there is this interdependence of various actions taken by the government that relates energy predictions to political, social, and economic activities both in the United States and abroad.

In summarizing this interdependence hypothesis, futures with respect to energy are far more dependent upon political, social, and economic factors than they are on specific technical expertise. This is an extremely important relationship for scientists and engineers to understand in order for their efforts to be effective. Most scientists and engineers recognize that there is a great deal that they can contribute to energy futures from the standpoint of increasing energy resources, bringing in alternative resources, and developing energy conservation schemes. These developments by scientists and engineers are not now and will not be in the next 20 years the driving factor for determining energy production and consumption.

The second hypothesis behind these predictions is that we are not faced with a major shortage of energy at the present time and will not be in the next 20 years. There may be cost and availability problems in bringing those resources to a proper application—whether they be resources in solar, fossil fuels, nuclear, or others. However, in our lifetimes and well into the 21st century, we are not faced with an actual shortage of energy. Many speakers on behalf of nuclear and solar energy, for instance, talk about the infinite supply that can be gained from solar energy systems or nuclear breeder reactors. Those claims, of course, do not mean very much until they are brought into actual operation. Thus, the second assumption is that there is plenty of energy for the foreseeable future.

The third hypothesis is that because of cost and availability situations, conservation and efficiency considerations relating to energy development will become more and more important in years to come. Out of this background assumption comes a very interesting conclusion which I will attempt to develop during the course of this presentation. Indiana has taken advantage of a low technology and high importation approach to energy historically, and therefore has the possibility of skipping many intermediate, complex high technology systems and going directly to relatively simple high efficiency systems for marginal energy developments. We have an interesting opportunity in Indiana that is not available to some other states that have gone into greater development of expensive synfuel, coal gasification, and nuclear systems.

The fourth hypothesis behind these forecasts is that Indiana will regain control of its own economy and once again experience a growth pattern in real terms after inflation.

Brief History of Energy in Indiana

Before embarking on energy futures, it is necessary to establish a base. Indiana has seen waves of energy production in coal, oil, and gas in various periods. Oil production had a major peak at the turn of the century and again in the 1950s and 60s. Natural gas production was heavy from 1890 through 1910. Coal production has been variable and long lasting and now shows signs of considerable expansion. The history of this production is sketched in Figures 1, 2, and 3.

Consumption patterns, on the other hand, have shown steady growth. Thus, Indiana went from a position of energy independence as a state at the turn of the century to a position of considerable dependence on external resources in 1960. Since that time, production has been growing at the same rate as consumption, with production amounting to roughly 25.0% of consumption. This enduring dependency on external sources is a contributor to the gradual relative decline in economic activity in Indiana. Energy consumption patterns in Indiana from 1960 to 1978 are described in Figure 4.

In terms of energy reserves, Indiana has a major resource in solar energy (which has been utilized in its agricultural industry), coal, oil shale, shale bearing uranium, and relatively minor natural gas and oil reserves. The oil shale conversion is just now entering early experimental stages, while uranium bearing shale is still

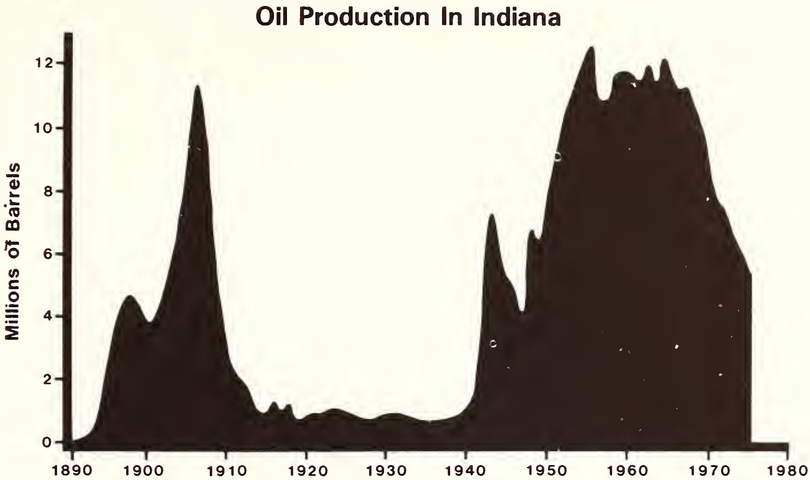

FIGURE 1. *History of Oil Production in Indiana* (SOURCE: Geological Survey, Department of Natural Resources, State of Indiana, Oil Development and Production in Indiana, Mineral Series No. 22.)

a research novelty. Solar applications, although growing, are limited by seasonal variations. Utilization of Indiana's energy resources shows promise of considerable growth in the coming decades.

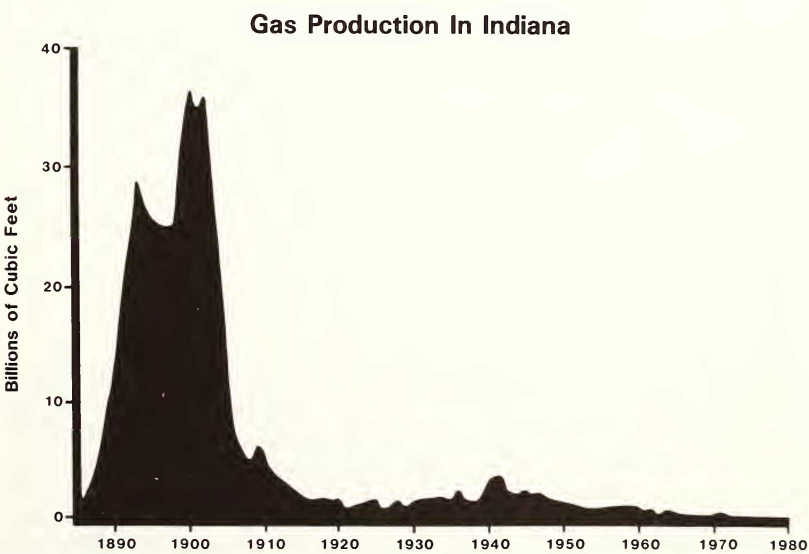

FIGURE 2. *History of Gas Production in Indiana* (SOURCE, Geological Survey, Department of Natural Resources, State of Indiana, Petroleum Industry in Indiana, Bulletin 42-N.)

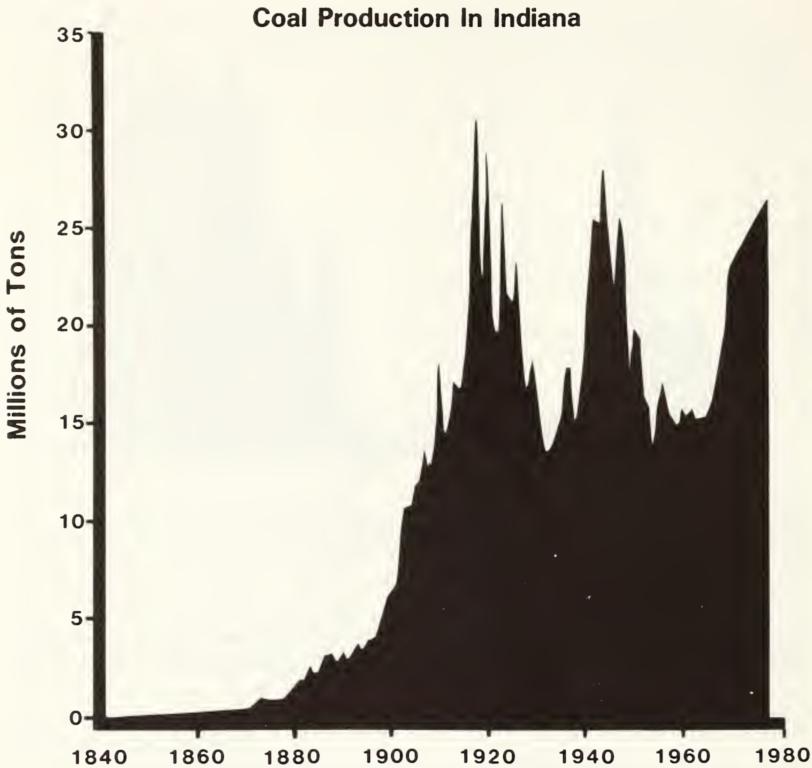

FIGURE 3. *History of Coal Production in Indiana* (SOURCE: Geological Survey, Department of Natural Resources, State of Indiana, Coal Resources in Indiana, Bulletin 42-I.)

Future Energy Patterns in Indiana

In order to maintain a robust economy in Indiana, a 3.0% annual growth in end use or work output from energy sources is required. For purposes of analysis, this growth can be split into three separate parts: (1) conventional fossil fuel consumption, (2) alternative fuels such as solar and nuclear, and (3) increased efficiency in obtaining end use work from conventional and alternative energy sources. Taking 1978 as a base for which firm numbers are available, Indiana's consumption of 2.66 exajoules will grow to an equivalent end use work output (if conversion efficiency remained constant) of 4.80 exajoules in the year 2000. Of this effective increase of 2.14 exajoules, only one sixth, or 0.37 exajoules will appear in standard energy consumption terminology. The rest will be a result of increased utilization efficiency. This change is outlined in Figure 5. The increase in fossil fuel consumption will be 0.22 exajoules to a level of 2.88 exajoules. At the same time, coal will partially replace oil in the fossil fuel category due to pricing pressures on oil. Alternate fuels, principally nuclear and hydro, will show rapid growth to a level of 0.14 exajoules or nearly 5.0% of total consumption. Before breaking these numbers out further, it is worthwhile here to discuss these three segments of the incremental effective energy growth.

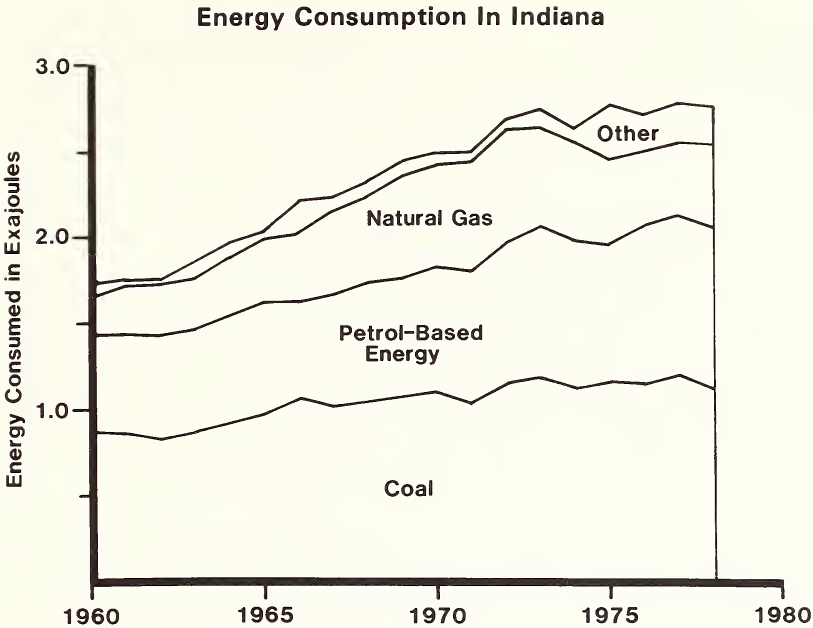

FIGURE 4. *History of Energy Consumption in Indiana* (SOURCE: Indiana Energy Consumption Data Base, SEDS.)

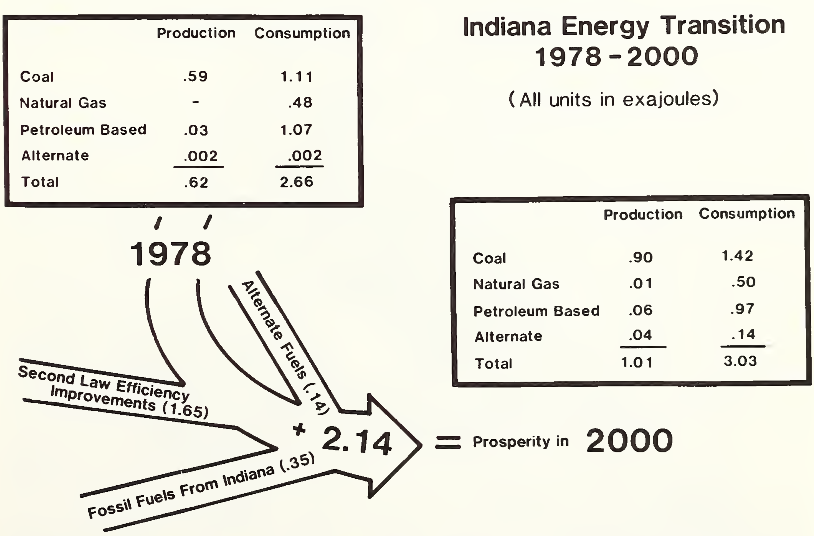

FIGURE 5. *Indiana Energy Production and Consumption—Prediction for the Year 2000.*

1. *Increased energy utilization efficiency.* By far, the most important aspect of this improved efficiency will be in the individual automobile fuel economy. Despite increases in the number of cars in operation, this segment will consume 10% less fuel by the year 2000. Another important activity will be the continued application of microprocessor technology to energy control. These applications will be on a wide range of devices and systems including heating, ventilating, and air conditioning equipment, industrial machinery, and boilers, and other energy conversion systems. An interesting example of this type of system is the residential environmental control by which portions of the home can be heated or cooled according to a programmed input from the homeowner.

Heat recovery systems represent another approach to enhanced energy efficiency. Heat exchangers are more expensive than microprocessors, but will grow particularly in industrial applications as the price of fuel increases. Heat pump applications represent another broad area of improvement in end use energy efficiency. Water sided pumps, in particular, will see growth both in new residential applications and in retrofit situations. A good example of this type of technology is the annual cycle energy system shown in Figure 6. This system provides heat by

A TYPICAL ACES INSTALLATION

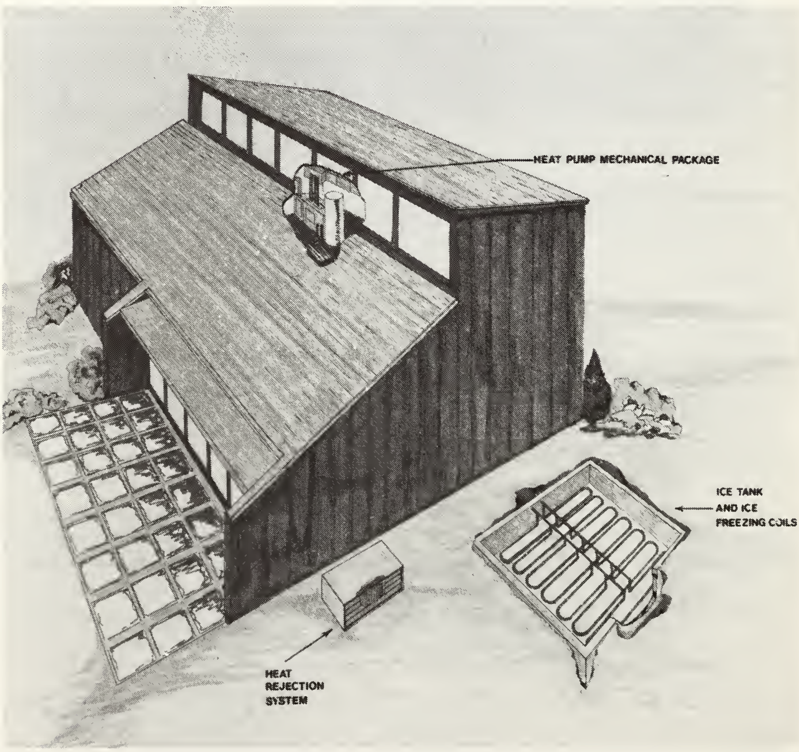

FIGURE 6. *Sketch of an Annual Cycle Energy System*

way of a heat pump in the winter through freezing stored water. The resulting ice is employed to provide cooling in the summer.

Another important set of systems for energy efficiency improvement is that of water heating. Pulse jet gas water heating and solar assisted water heaters are two important examples of these systems. A typical solar system is illustrated in Figure 7.

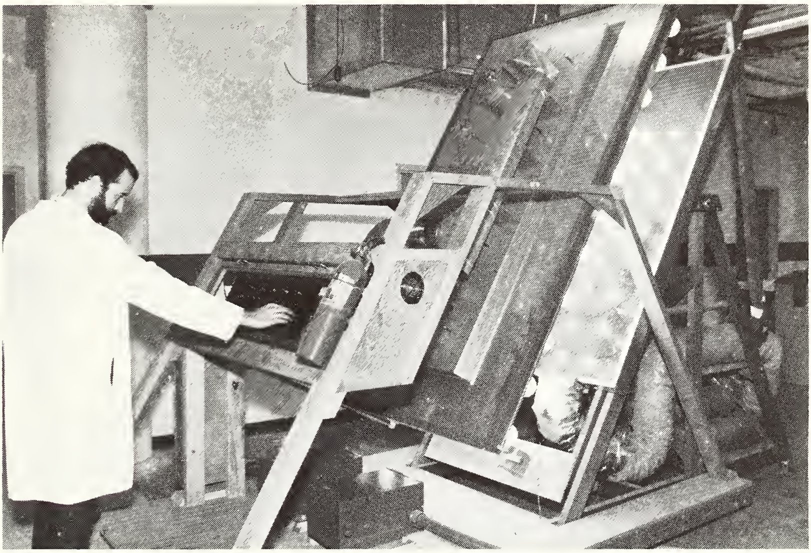

FIGURE 7. *Solar Hot Water Collector under Test at the Indianapolis Center for Advanced Research*

2. *Alternative energy supply.* Solar energy through hydro power presently supplies approximately 0.2% of the energy produced in the state. This amount will rise to 0.01 exajoules due to low head hydro applications by the year 2000. No nuclear electric power is generated in the state at present, but a very small amount is imported from Michigan. Through the addition of one gigawatt-year of nuclear electric power generated in the state, imported uranium will supply 0.10 exajoules or 3.0% of energy consumed in 2000. Alcohol fuels, steam from urban waste, wood combustion, and small amounts of wind and photovoltaic electricity will make up the remaining 0.03 exajoules of nonfossil fuel sources.

3.*Conventional Sources.* Through the growth in use of heat pumps, electric transport and microprocessor controls, coal consumption will grow significantly in the next two decades to about 1.4 exajoules from a present value of about 1.1. Since nuclear will add 0.10 exajoules and efficiency increases in production of electricity will add another 1.0%, the growth in electricity consumption will be 1.7% per year during the next two decades.

On the production side, Indiana will strive to gain back its balance of energy with other states. This will result in holding imports to their present level of a little over 2.0 exajoules. Through large increases in coal production, small hydro increases, and doubling of gas and oil production due to greatly increased exploration in reaction to higher prices, production will increase to 1.01 exajoules. Thus, coal production will grow by 2.1% per year over the next 20 years to a level of 0.90 exajoules per year or 42 million tons per year. This will result in total production of 1.01 exajoules or roughly one third of consumption.

Environmental and Economic Consequences

Other important aspects of these conclusions fall into the categories of environmental and economic concerns. The first major analysis from the environmental standpoint is the measurement of heat throughput. Based on this study, that throughput will increase by approximately 16% to a level of 3 exajoules in 2000. Assuming a 10% utilization efficiency in 1980, this means a growth of 0.22 exajoules to a level of 0.48 exajoules end work output in 2000. This will be achieved by an increase in energy utilization efficiency to a value close to 16.0% in 2000. Thus, there will be no major environmental effects due to thermal throughput.

The second major environmental analysis must be to review the increased energy production. This will be primarily coal. Much of this coal will be strip mined. Since adequate environmental regulations concerning strip mining now exist, the cost of Indiana coal will remain high and thus, moderate expansion of the levels predicted in this paper of 2.0% per year.

Another result will be a vigorous "mining" of old abandoned coal. These fields which hold massive reserves of coal on the surface in Indiana where entire coal mines once existed will be mined extensively because of cost advantages derived from environmental laws. By the year 2000, this effort will probably yield production levels of 2 million tons per year. Thus, in all likelihood, the net effect of increased coal production will be an actual increase in available land.

The third environmental factor to consider is the shift in consumption from oil to coal. This increase in coal consumption will take place for the most part in electric generation. Present air quality regulations are set to meet external environmental questions such as "acid rain" in the Eastern United States or Canada, or microparticulate problems immediately to the East. Thus, no changes in air quality will be felt in Indiana. Costs of Indiana electricity will be affected by these regulations. These higher costs will also moderate growth.

Other environmental questions related to increases in oil production and alternate fuels are minor. In summary, the result of this change to higher utilization efficiency will bring about minor net improvements in the overall environmental quality of the state.

The economic effect of these moves toward greater utilization efficiency and energy independence will be to provide a basis for growth. Indiana's economy will grow gradually in the 80s and more rapidly in the 90s. The major items produced to accomplish these energy results will be in electronics, computers, and related transducers. A second set of products to be produced will be heat transfer equipment; including regenerators, combustion nozzlers, compressors, storage vessels, and solar collectors.

Conclusions

Thus, this set of predictions closes on itself. Indiana will grow in its production of these items while holding its own in heavy industrial units now produced. The growth industries for Indiana will be electronics, coal, gas, and oil exploration and modular heat transfer equipment.

In conclusion, a few words should be said about "beyond 2000." The set of activities unleased by this energy future will still be building at that time. Transport, agricultural, heating, and ventilating, and industrial energy schemes with energy utilization effectiveness of 25.0% to 50.0% are achievable. Further, a small, but growing alternate energy business will be in place ready to grow. Economic growth will continue with alternate fuels gradually replacing energy utilization efficiency improvements as the driving force in the economy in the mid 21st century.

A set of assumptions, an assessment of the status of energy in Indiana and a subjective regressive study has resulted in a set of predictions showing an attractive future for Indiana.

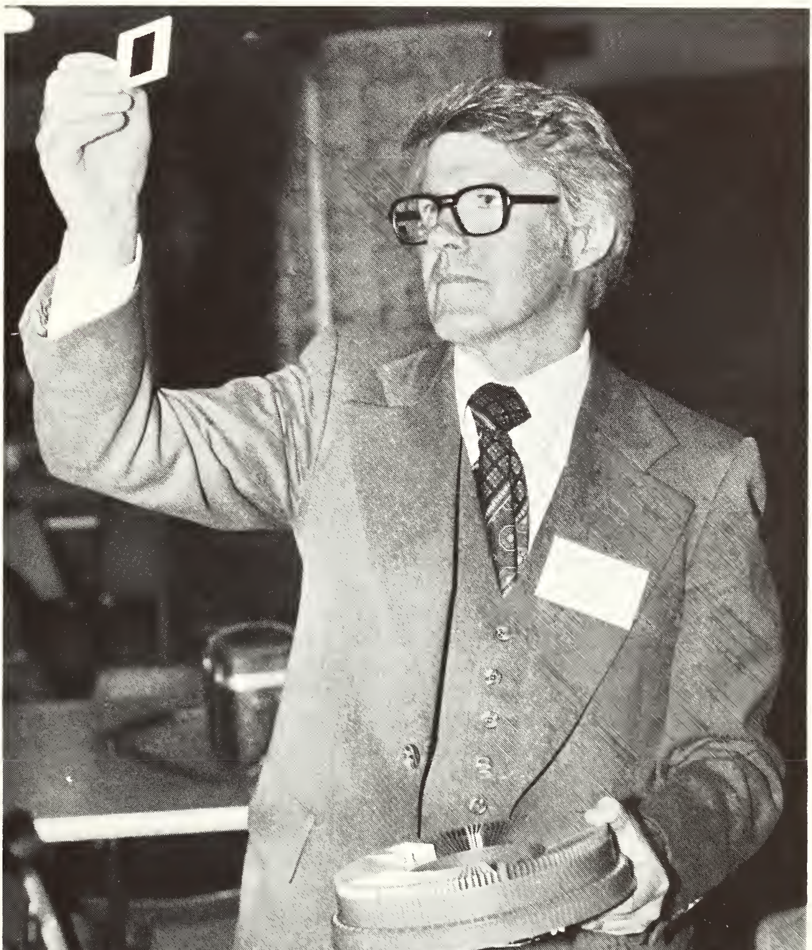

Photo by Lloyd Anderson, IAS

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Robert E. Henderson checks the transparencies prepared for use with his Presidential Address, "The Energy Future for Indiana."