information necessary to establish reasonable human exposure guidelines.

Research on the health risks associated with exposures to substances produced in coal conversion and oil shale recovery processes will also provide a firm basis for the development of exposure control guidelines for workers in these industries. It is important for the orderly development of safe working conditions that the health-effects research precede the large-scale deployment of fuel production facilities.

Coal Gasification Procedures have been developed and their validity demonstrated for (1) analyzing chemical toxicants in compound mixtures, (2) monitoring human and environmental exposures, and (3) mitigating exposures and their effects. These procedures have been proven effective in characterizing the toxic chemical species in the process and effluent streams of coal gasification pilot plants and process development units.

History Epidemiological information on workers in turn-of-the-century coal gasification plants (in England and Japan) and more recent experience in coking operations indicated that a coal gasification industry might present significant potential for adverse human health effects (e.g., increased incidence of lung and bladder cancer). Likewise, the tremendous amounts of coal that would be consumed in a gasification industry suggested that the entire conversion system had potential to create a number of adverse environmental impacts.

In the mid-1970's OHER initiated a broad program of health and environmental studies at operating coal gasification development units and pilot plant facilities to obtain definitive information on the potential health effects of modern coal gasification technology. These studies, which use state-of-the-art toxicological and ecological testing methods and procedures, are coordinated with and complementary to, studies supporting the development of advanced high-Btu and low-Btu coal gasification technology.

Studies to identify and characterize the extent of toxins in gaseous products from coal focused on the potentially carcinogenic organic compounds in process streams and effluents. Ecological studies addressed the effects of air emissions, liquid effluents, and solid waste disposal. Industrial hygiene studies included workplace monitoring, medical surveillance, and evaluations of the adequacy of measures to limit exposures and effects. Finally, an initial risk assessment of coal gasification was performed.

Benefits As a direct result of the studies at pilot plants, toxicological evaluation of process streams and effluents from full-scale gasifiers can be limited to screening tests for most streams. Detailed analysis is necessary only for those streams or stream components with previously identified toxicity. This practical research has established that (1) the mutagenicity of organic compounds is limited principally to chemicals called the higher molecular weight polynuclear aromatic hydrocarbons, making it necessary to study and characterize the toxicity of less than 1 percent of the material found in most process streams, and (2) the more volatile hydrocarbons found in the process stream (e.g., naphtha with up to 1000 tons/day output) do not contain new toxins, need not come under Toxic Substances Control Act regulations, and thus will not require extensive toxicological study.

This means that it should be possible to design facilities to recover these commercially valuable chemicals rather than burn them as in-plant fuels or to dispose of them as waste materials. The evaluation of process streams for toxins has also been greatly simplified by the development of sophisticated procedures for separating the complex coal-derived products and isolating and identifying toxic chemicals. New instruments for vapors and liquids have been developed and field-tested for monitoring contamination by polynuclear aromatic hydrocarbons in the workplace. These instruments provide a simple method for directly evaluating exposure and can monitor the effectiveness of mitigating procedures, which is almost impossible without such instrumentation.

Ecological studies have indicated that the effects of atmospheric emissions on vegetation decrease with decreasing humidity. Thus, judicious site selection criteria could yield economies in emission control requirements without sacrificing air quality.

Evaluation of environmental control technologies has provided information that will permit health and safety considerations to be incorporated in process design. In a low-Btu industrial gasifier, commercially available cleanup devices have been shown to be effective in removing materials of health and environmental concern. On the other hand, solvent extraction of wastewater from tar-producing gasifiers does not completely remove all products of potential concern; further treatment may be required before discharge to the environment. Similarly, leaching of the large amount of solid waste produced in a commercial-scale facility might in the long term have adverse environmental effects even though the concentration of toxins in the waste is low.

As a result of the knowledge gained through this program, the scope of health and environmental studies required at any future full-scale commercial facilities will be greatly reduced, information on toxic substances and their location in the product or waste stream is available, validated methodologies are available for obtaining meaningful data, sophisticated procedures for isolating and identifying toxins have been developed, and many of the problems that can be prevented by careful plant design are known.