KEYSTONE: A VIABLE COAL-TO-METHANOL PROJECT

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Introduction

The Keystone Project is a coal-to-methanol synthetic fuel plant currently being planned for construction in Western Pennsylvania. The coal will be converted to synthesis gas in a Westinghouse fluidized-bed gasifier and then, using the ICI process, to methanol, which will be marketed as a substitute for petroleum-based fuels. By-products will include sulfur, ammonia, and carbon dioxide.

Initially, a commercial prototype module will be built to produce approximately 13,000 barrels of methanol per day, utilizing about 2400 tons per day of high-sulfur bituminous coal available in the Western Pennsylvania region. Subsequent expansion of the plant to as much as 67,000 barrels per day, using 5 modules, is planned as the market for methanol increases.

The Keystone Project Team was organized early in 1980 and is now at work on a Feasibility Study under a $4.8 million grant from the U.S. Department of Energy to define engineering, environmental, resources, marketing, financial and socioeconomic parameters of the project. This study is scheduled to be completed by late 1982. Participants in this study, headed by Westinghouse Electric Synthetic Fuels Division, are:

- Dravo Engineers & Constructors – Architect Engineer
- Davy McKee Corporation – Methanol Production
- Air Products & Chemicals, Inc. – Air Separation Plant
- AmeriGas, Inc. – CO_2 Recovery
- Bethlehem Steel Corporation – Coal, Railroads
- Energy Impact Associates – Environmental
- Johnstown Area Regional Industries – Community Relations
- Lehman Brothers Kuhn Loeb Inc. – Financial and Economic
- Westinghouse Electric Corporation – Project Management, Gasification

On June 1, 1982, Westinghouse Electric Corporation, on behalf of the Keystone Project Team, submitted a proposal for loan guarantees and price supports to the U.S. Synthetic Fuels Corporation. The SFC Board met on July 15 to deliberate on the proposals from twenty-nine second round applicants for

SFC financial support. With regard to the Keystone Project, the Board noted that while Keystone should be encouraged, the engineering design was not sufficiently completed to allow an accurate assessment of costs. It was also noted that the Project should be mature enough to resubmit a proposal in response to the third round solicitation expected to be issued in September for submittal in December, 1982.

Additional details on the engineering design effort, as well as plant siting, scheduling, and marketing are provided in the ensuing sections.

Plant Design

Most of the world's supply of methanol today is produced from reacting natural gas with steam in the presence of a catalyst to produce carbon monoxide and hydrogen, which is then converted to methanol by a commercially-proven technology. In the Keystone plant, the main exception in producing methanol is that the carbon monoxide and hydrogen will be produced by the gasification of coal. A simplified block flow diagram of the process is shown in Figure 1.

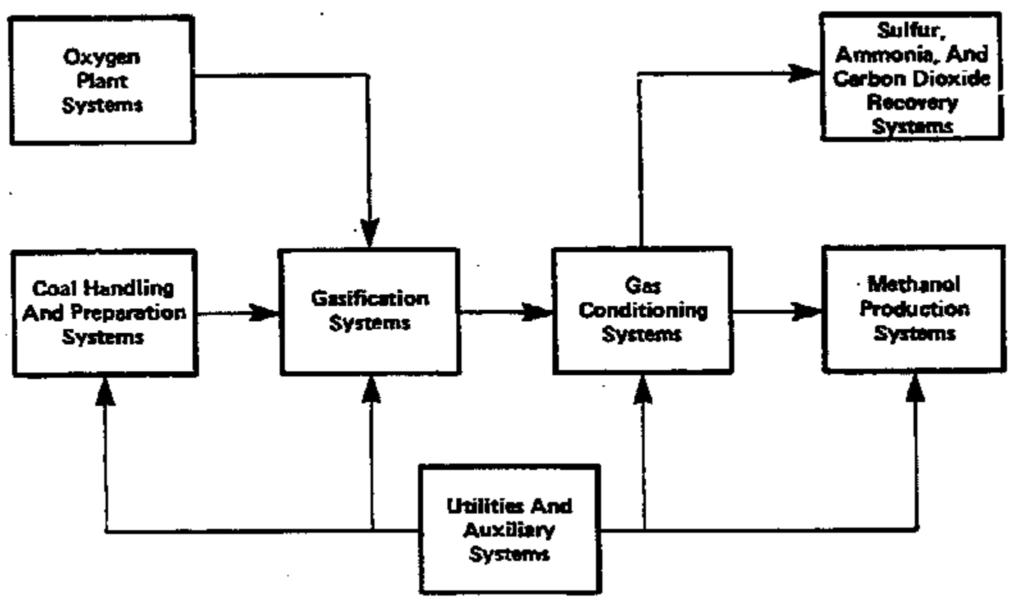

Figure 1. Simplified Block Flow Diagram of Keystone Plant

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Coal is received and unloaded into an active storage pile. It is then crushed to a quarter inch in size or smaller and, if necessary, dried to ensure flowability through the pressurized coal lockhopper system.

The crushed coal is pneumatically transported into the gasifier, where it is reacted with oxygen and steam, respectively. Inside the gasifier, combustion of a portion of the incoming coal provides the heat necessary to devolatilize the remainder of the incoming coal to form a char and to react the char with steam to form hydrogen, carbon monoxide and other gases.

Although the Westinghouse fluidized-bed gasifier utilizes advanced, high performance technology, the gasifier itself is a simple carbon steel pressure vessel, lined with refractories commonly used in intermediate temperature (1800°F) processes. The fluidized-bed operation with its large inventory of carbon is inherently stable and simple to control, yet responds readily to process load demand changes and can easily be operated at partial-load conditions. Ancilliary equipment also employs standard piping, valves and other components in configurations that have been tested through thousands of cycles at the Westinghouse facilities in a development program that dates from 1972.

The most current development in the gasifier scaleup program, as discussed by Westinghouse in another session, is the current effort to demonstrate a commercial-scale Westinghouse gasifier. This program will offer unique advantages for the Keystone Project as well as for future synthetic fuel plants that include low capital and operating costs, minimal environmental impact, and operational safety and reliability.

The gasifier operates at moderate temperatures when compared to the entrained or slagging gasifiers. The Westinghouse gasifier has the advantage of less materials selection problems, an extended refractory life by an order of magnitude, and more efficient operation because less carbon is combusted to produce the heat required for gasification. The Westinghouse gasifier has an advantage over low-temperature, fixed-bed gasifiers, such as moving dry ash gasifiers, because the fluidized bed operates at a temperature above those in which toxic phenols, tars and oils are produced. This avoids the in-plant toxicity hazard and a concommitant penalty in capital cost and efficiency because of tar-oil cleanup systems.

As the bed of char circulates in the gasifier, the carbon in the char is consumed by combustion and gasification, leaving particles that are rich in ash. The unique fluid dynamic design of the gasifier allows the ash-rich particles to coalesce with each other and form larger, denser particles, which drop out of the bed and collect in the ash annulus for disposal. The ash is collected as a dry, granular, and environmentally-benign material that can be disposed onsite or utilized for a highway anti-skid material or as a lightweight aggregate.

Raw product gas exits from the top of the gasifier where fine, entrained particles are removed. The 1900°F gas next passes through the raw gas heat recovery exchange area, where it is cooled by a series of heat exchangers that generate superheated steam for process use. The final cooling and particulate removal of the gas takes place by direct water quench in a venturi scrubber prior to desulfurization in the acid gas removal system. The raw product gas quench removes any remaining particulates. The gas is then shift-converted catalytically to adjust the hydrogen-to-carbon monoxide ratio to 2.4:1, and then cleaned in a Selexol system to remove hydrogen sulfide and carbon dioxide. Elemental sulfur, carbon dioxide and ammonia are recovered as by-products.

The clean and shifted product gas enters the methanol synthesis unit, a low-pressure reactor that catalytically produces crude methanol. After simple distillation, methanol is stored for sale as fuel or chemical feedstock.

There are numerous auxiliary systems that support the main coal-to-methanol processing system. The various gas conditioning facilities operating in the plant produce anhydrous ammonia and elemental sulfur at a level of purity that is acceptable for outside sales. Also, carbon dioxide is recovered from the process and sold for food processing and, as markets develop, to enhance oil well recovery.

The remaining support systems must handle the plant wastes. The Keystone plant wastes that do exist are non-toxic to the environment. The solid wastes, consisting primarily of coal fines, can be handled by conventional on-site disposal methods and present no threat to the environment. The liquid wastes from the various water systems throughout the plant are handled via conventional water treatment with the intent to maximize water reuse.

Several aspects of the Keystone Project design make it particularly attractive for methanol production:

- The Westinghouse gasifiers operate at over 500 psi, thus significantly reducing compression requirements for synthesis gas going to the methanol loop as compared to those for lower pressure gasification processes.

- The virtual absence of tars and oils in the product gas results in water treatment processing much less complex than that for a downflow fixed-bed gasifier.

- Complete coal utilization is achieved through the ability of the gasification process to accept fine coal not suitable for fixed-bed gasification.

- Heat recovery on the gasification system and the steam-methane reformer in the methanol system, together with the availability of imported electrical power for the oxygen plant, eliminate the need for a coal-fired boiler plant for the Keystone Project. This results in elimination of the environmental permitting and capital investment associated with stack gas scrubbing for desulfurization.

- The gas quench system produces a shift feed which is saturated with water at over 300°F, resulting in a reduction of steam addition for shift conversion.

- A steam-methane reformer treatment of methanol loop purge gases results in a high carbon utilization and significant steam generation. In essence, the reformer doubles as a purge gas recovery unit and a steam generation plant.

Siting

A 1340-acre plant site has been selected from a number of currently-available sites in the region that are known to have sufficient land, water, coal, transportaton, labor, and other resources for the project for at least a 20-year period. All of the required land is under option with the various property owners. The site is located near Cairnbrook, Pennsylvania, about seventy miles east of Pittsburgh, and is within the bituminous coal belt of Pennsylvania, with resources of 7 billion tons of coal, all of which is within easy transport distance to the plant site. High sulfur coals, for which there is currently no market, are available in this area and are ideal for this application. Parameters for the design basis coal are given in Table 1 including 4.52 percent sulfur.

TABLE 1
DESIGN BASIS COAL PROPERTIES

Proximate Analysis	Design Basis
Volatile Matter (%)	19.09
Fixed Carbon (%)	61.91
Ash (%)	14.00
Moisture (%)	5.00
Ultimate Analysis (DAF)*	**Design Basis**
Carbon (%)	85.35
Hydrogen (%)	4.93
Oxygen (%)	3.83
Nitrogen (%)	1.30
Sulfur (%)	4.52
Chlorine (%)	0.07

Heating Value: 12,300 Btu/lb

* Dry, ash-free basis.

Environmental

An Environmental Regulatory Compliance Plan has been developed for the Cairnbrook site with input from regulatory agencies to identify required permits and their schedule for approvals. There are no impediments to full regulatory approval of the Project, based on current plans for treating and handling liquid and solid wastes as well as gaseous emissions.

The Westinghouse gasification process is inherently non-polluting. Tests conducted at the Westinghouse Process Development Unit confirm that, at the temperature regimes of the gasifier, tars and other organics are largely consumed. Ash can be disposed without adverse environmental impact and potential air pollutants can be removed within the plant's environmental control system.

Meteorological monitoring equipment is currently operational on site. Considerable data has been collected during the winter and spring seasonal aquatic and terrestrial surveys. Site-specific work on geology, geohydrology and soils is underway. A comprehensive environmental report is being prepared.

Employment

This area offers an abundant supply of skilled labor within easy commuting distance to the plant, and it is expected that few changes to the infrastructure or to the socioeconomic patterns of the surrounding communities will occur as a result of the project, other than a general strengthening of the economic welfare of the area. Enthusiastic support has been received from local businesses, labor and community organizations. The project will initially employ approximately 400 operational employes, 1900 construction employes, and several hundred miners.

Schedule

Based on obtaining full authorization and financial backing for the Project by October 1983, the schedule calls for construction of the first module to begin in April 1984, with commercial methanol production starting in December 1986. This compressed schedule is made possible by the modest plant size and its extensive use of commercially-available technology and systems. (See Figure 2.)

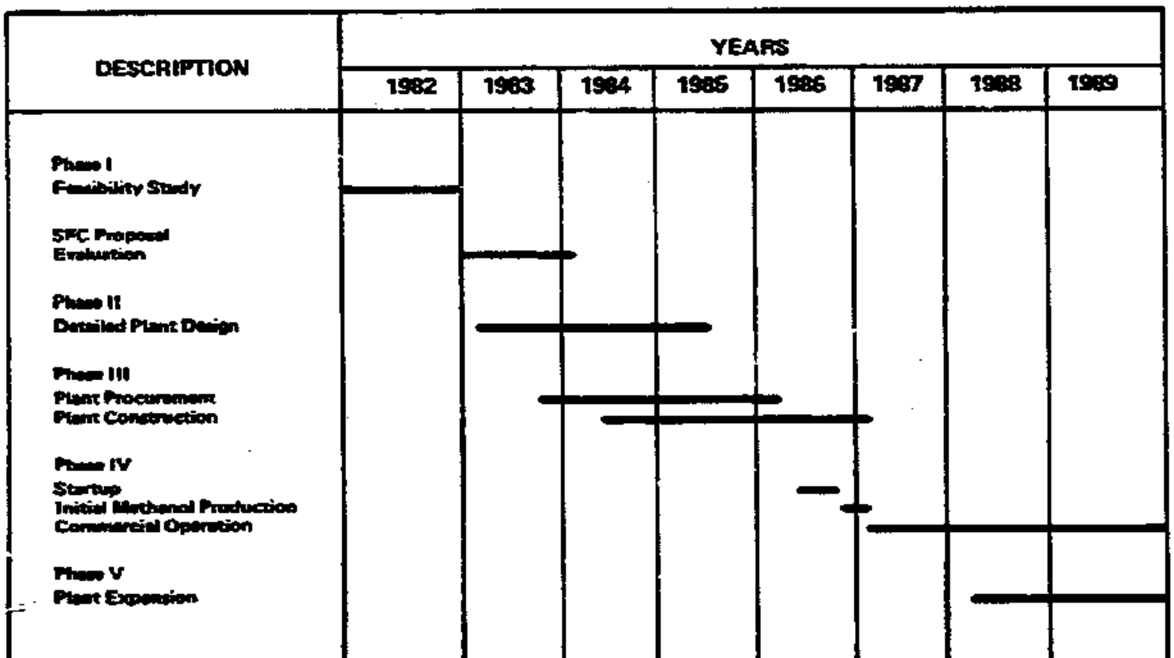

Figure 2. Keystone Project Schedule

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Ownership

Ultimately, the Project will be owned by a partnership of equity contributors now being formed. Activities are underway to attract the equity capital required from companies that have expressed interest in the Project. Prospective partners include several large organizations experienced in the development of major energy facilities, who will also contribute personnel and expertise to assure successful Project completion.

Financial

Current capital cost estimates for the Project indicate that one module will cost approximately $500 million. Engineering design efforts are currently underway to further refine this estimate.

The financing structure of the Project will be based on a 75% debt/25% equity ratio. The equity portion of the Project will be shared with general and limited partners. General partners will provide more than 50% of the equity, and it is expected that Westinghouse will be the lead general partner. Current steps are being taken to identify other prospective partners.

Based upon the currently proposed financial structure, the projected plant selling price of methanol is 85¢/gallon for the base case study. Current market price for methanol is 71.5¢/gallon on the spot market and 79.5¢/gallon with the contract market.

Marketing

The plant will be located in a highly industrialized and highly populated area of the country. The Keystone Project site is within 500 miles of 70 percent of the nation's population. Markets are available for methanol or other products from the plant within relatively easy transportation distances. These markets will include transportation vehicles, which can use the methanol as a blend with gasoline or diesel fuel or, with engine conversions, as fuel-grade (99.5 percent) methanol. Considering all the internal combustion engines in the U.S., the potential market is enormous: about 6 million barrels of gasoline and diesel per day—equivalent to the output of 120 big synfuels plants.

In addition, methanol fuel is suitable for use as a combustion turbine fuel, a boiler fuel, or as a fuel for on-site or marine power trains used in industrial, defense or merchant marine applications. A number of promising markets have been identified that can assure full utilization of the Project's output, given appropriate price incentives. A nearby petroleum products pipeline provides an economic means of methanol distribution to various users.

You may wonder who needs methanol. After all we keep reading about a world oil glut. Regular gas is around $1.20 a gallon.

There is an oil glut that will continue for another year or two. The oil glut is currently resulting in lower energy prices; however, the current situation won't last indefinitely. Energy demand in the developed nations has slowed dramatically over the last decade, but this is not as true of the developing nations like Taiwan, South Korea and South Africa, where economic growth rates are still relatively high. In addition, as Europe and the U.S. move out of the current recession, demand will begin to catch up with supply once again.

A further concern is the destabilizing effect which the glut may have on many of the oil producing nations. The social programs in Mexico, Venezuela and Indonesia, for example, are literally fueled by oil exports. As export revenues decline, the social programs are jeopardized. Does this mean that OPEC is going to fall apart? That's possible, but it's more likely that an already tenous situation in the Middle East will become still less secure.

The result will be that oil prices in the future will be even more volatile than they have been in the past. Prices are influenced by a relatively few large oil inventory holders and as demand catches up to supply in an uncertain political environment, we're going to see large swings in price. Sometimes down, but more frequently and inevitably up.

Many knowledgeable observers forecast that world oil prices will increase about three percent greater than the rate of worldwide inflation. If the real price of coal increases only one percent a year for the next couple of decades, that two point spread is enough to drive a large synthetic fuels industry into the world economy even if oil is relatively available. The reason for this is that a large portion of the initial cost of synthetic fuels is the capital cost of the plant. Once the plant is built that cost is inflation resistant because the money has been spent. Thus, as time passes, the capital cost is a smaller and smaller portion of total cost. The other principal cost is coal which, we've said will increase 2% less than the competing commodity. So, whatever the profitability of the synfuels plant at start-up, it will become more profitable as time goes on. A good example of this phenomenon is the world's first large scale synthetic fuel plant, SASOL I in South Africa. This plant started up in 1955 and struggled economically in the late 50's and early 60's with world oil prices at $1 per barrel. Now, that plant's annual profits are greater than its initial capital cost.

Aside from the economic security and stability which a synthetic fuels industry would provide to the United States, there are significant employment ramifications. Sixty plants like our Keystone Project would require 48,000 operating people, 90,000 miners and something like 40,000 construction workers, not to mention the thousands of jobs associated with producing the hardware, structural steel, concrete and a thousand other things which would go into these plants.

With proper planning and forethought, technology development, site identification, manpower acquisition, and equipment manufacturing capacity, an infrastructure can be in place in anticipation of a disruption of imported oil. At the same time, this would provide vitally needed jobs in the United States.

We're enthusiastic about the prospects of pioneering a major synthetic fuels industry in Western Pennsylvania, and we're anxious to make it happen.