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Author(s): L. E. Van Bibber, F. E. Bernard, R. R. Holman, R. Putkovich, D. A. Wiseman, W. D. Jackson, G. R. Seikel, J. Cuchens, C. Maxwell, and N. Johanson

Session Name: Plant Engineering Studies

SEAM: 27 (1989)

SEAM EDX URL: https://edx.netl.doe.gov/dataset/seam-27

EDX Paper ID: 1367

CONCEPTUAL DESIGN OF THE SCHOLZ MHD RETROFIT PLANT

L. E. Van Bibber, F. E. Bernard, R. R. Holman, R. Putkovich, D. A. Wiseman
Westinghouse Electric Corporation
W. D. Jackson - HMJ Corporation
G. R. Seikel - SeiTec
J. Cuchens - Southern Electric Integration
C. Maxwell - STD Corporation
N. Johanson - University of Tennessee Space Institute

Abstract

To evaluate the technical feasibility of an MHD system operating in a commercial electric-utility environment, Westinghouse conducted a site-specific conceptual design study under contract with the Department of Energy's Pittsburgh Energy Technology Center. The study involved the retrofit of an MHD system to an existing coal-fired power plant, the Scholz Generating Station, which was selected following evaluations of more than 200 sites. Located in Sneads, Florida, approximately 45 miles west of Tallahassee, the Scholz plant is owned by Gulf Power Company (a subsidiary of the Southern Company).

The design team assembled by Westinghouse for the study included Southern Electric International (the architectural engineering arm of the Southern Company), University of Tennessee Space Institute, SeiTec, Inc., HMJ Corporation, STD Research Corporation, and Westinghouse Research and Development Center.

Following site selection, the team performed technical analysis, evaluation, design, and calculations in sufficient detail to assess the operational characteristics, environmental effects, and economics of a coal-fired, MHD system utilizing Illinois No. 6 coal as the feedstock. Produced during the study were process, system, and equipment descriptions; a plant layout; and cost and schedule data for design, fabrication, installation, and initial operation.

The study found that an MHD retrofit can demonstrate the technology basis for future commercialization of MHD.

Retrofit of an MHD system to Scholz's conventional steam plant would significantly increase plant performance, providing a higher net power output through increased thermal input. Because higher efficiencies are attainable, environmental emissions would be substantially reduced, since less coal would have to be burned. In addition, inherent in the MHD process is the ability to remove sulfur during combustion. This allows for the control and reduction of sulfur dioxide emissions, as well as for the safe and economical use of high-sulfur, high-energy eastern coals.

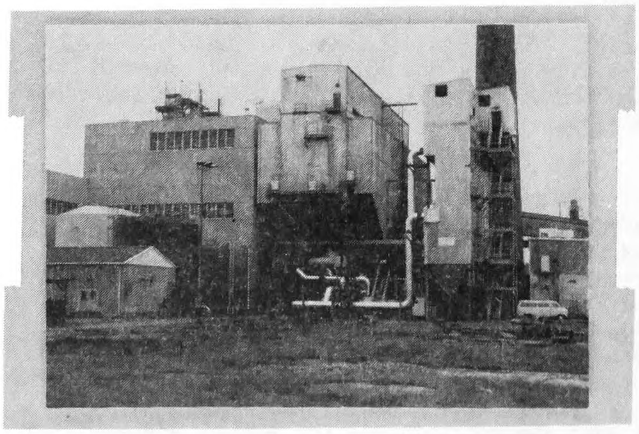
Implementation of an MHD retrofit project at Scholz Generating Station will provide the opportunity to verify safe, reliable, and efficient operation and demonstrate the principles of a stand-alone system under commercial operating conditions. An operational state for prototype retrofit can be attained in as little as seven years at a cost of less than $170 million.

BENEFITS

- Plant efficiency can be increased with an MHD retrofit
- Environmental emissions, both gases and particulates, meet new source performance standards
- High-energy, high sulfur eastern coal can be used safely and economically
- Operational status can be reached in less than seven years
- Existing plant availability will not be impacted during retrofit and testing, allowing high plant-capacity factors to be maintained
- Overall project costs for this first-of-a-kind retrofit can be held to less than $170 million

The Study Concluded that MHD Affords Unique Technical and Environmental Benefits at Reasonable Cost and Schedule

THE SCHOLZ GENERATING STATION IS AN IDEAL FACILITY FOR AN MHD RETROFIT.



The MHD System can be Easily Integrated with the Existing Equipment, such as the Electrostatic Precipitators and Boilers, without Impacting Plant Availability.

Typifying many older coal-burning plants in the southeastern utility region, the Scholz plant has been used for previous development programs, the most recent being the Electric Power Research Institute/Southern Company Services baghouse project. Plant personnel are therefore experienced in first-of-a-kind demonstrations.

Easily accessible by Interstate Highway 101 and serviced by railroad lines and barges via the adjacent Apalachicola River, the site contains an abundance of level solid land. No special drainage or environmental problems are evident.

An Open Flat Area Adjacent to the Boiler Room and Electrostatic Precipitators is Available for the MHD System Retrofit.

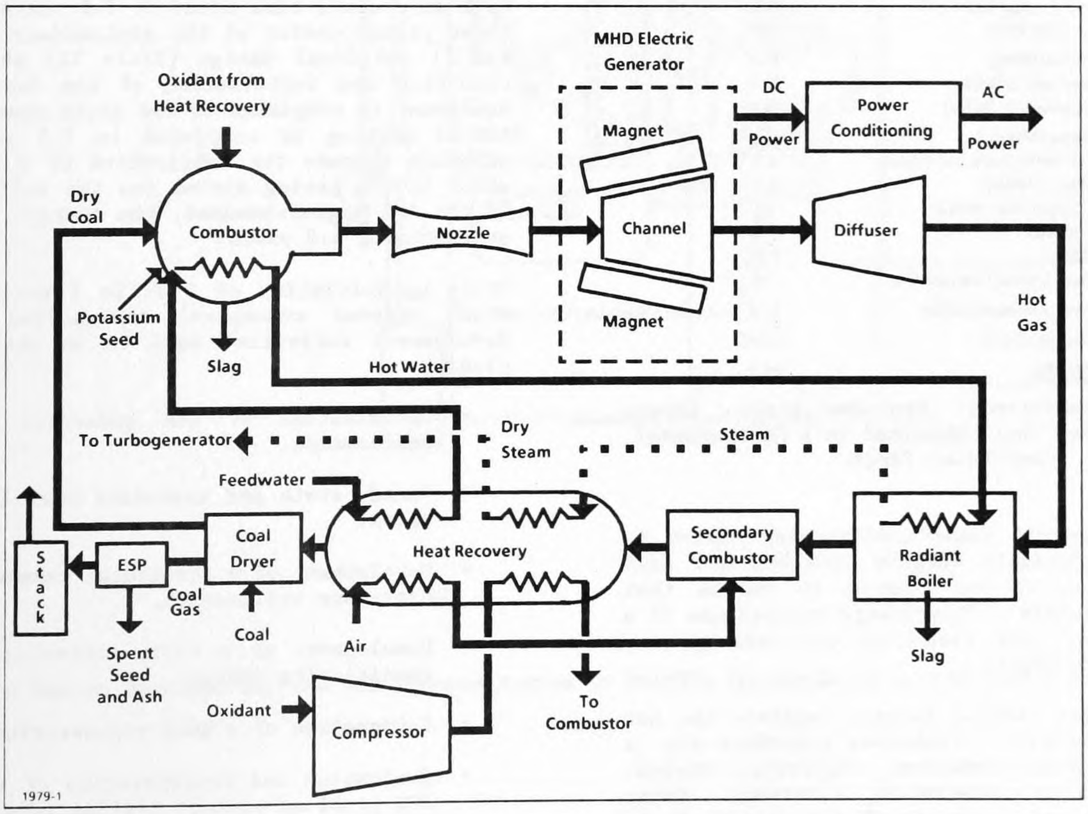
The Scholz plant contains two identical coal-fired steam turbine-generator units rated at 46 MW each. Both are well maintained and operating efficiently. Each contains a separate Babcock & Wilcox boiler system, General Electric 900°F/850 psia non-reheat steam turbine, and independent control system. The units are independently dispatched from the Southern Company's dispatch facility in Birmingham, Alabama. In operation since 1953, the units employ Illinois No. 6 coal and operate in a base load mode at 50 MWe. Overall plant efficiency is 28 percent, with an annual capacity factor in excess of 75 percent.

The plant is highly reliable and existing facilities such as the feedwater system, steam turbines, condensing system, electrostatic precipitators, control room, draft fans, stack, and coal handling system can be used for both the Scholz units and the MHD system.

The Scholz station is already designed for tandem operation of the boilers, so that steam flow can be fed to either of the turbine-generators. This provides added flexibility in the sizing and integration of the MHD system.

SUCCESSFUL RETROFIT OF SCHOLZ PLANT UNIT TWO WILL VERIFY THE OPERATION OF THE MHD POWER GENERATION PROCESS IN A HIGH GROWTH UTILITY ENVIRONMENT AND ENHANCE IT POTENTIAL FOR COMMERCIAL USE.

Westinghouse's MHD system retrofit was designed to add 24.4 MW in gross power to Unit Two at Scholz.



Several Design Features Incorporated in the MHD System Process Enhance Cost-Effectiveness and Reliability

The major subsystems that will be installed include the combustor, an integrated generator, power conditioning, control system, heat and seed recovery systems, and auxiliary systems. Integration of the MHD system with the existing plant is by a steam side connection. The system was sized to provide sufficient steam to produce 50 MWe from the turbine.

The combustor, a two-stage slagging type currently under development by TRW, is supplied with a 40-percent oxygen-rich oxidant that is compressed to 6 atmospheres and preheated to 1450°F. Illinois No. 6 coal is combusted to a stoichiometric ratio of 0.88, K_2CO_3 seed added to provide the required plasma electrical conductivity. A K_2 to S molar ratio of 1.0 is achieved, minimizing boiler plugging problems.

The electrically conductive plasma is delivered to a structurally integrated MHD electric generator, where a nozzle accelerates it to Mach 1.7. The generator features a replaceable channel that is designed for a 4000-hour life and is efficiently integrated into the bore of the magnet. Generated within the field of the 6.4 (peak) Tesla superconducting magnet is 25.6 MW of DC power. The magnet is a circular-saddle field-coil design similar in configuration to the successful 6-Tesla, 5-meter-long magnet now in excess status and stored at Argonne National Laboratory (ANL) as excess equipment. With minor modifications, this existing magnet could be used in lieu of constructing a new magnet.

PERFORMANCE SUMMARY FOR RETROFIT UNIT	
Coal	Illinois No. 6
HHV (Btu/lb)	11,241
Operating Pressure (ATM)	6
Oxygen Enrichment (Mole %)	40
Oxidant Preheat Temperature (°F)	1,450
Coal Thermal Input (MWt)	192
Power Generated (MWe)	**74.4**
MHD Generator (MWe)	24.4
Turbine-Generator (MWe)	50.0
Power Consumed (MWe)	**14.8**
Magnet, Transformers, Etc. (MWe)	0.3
Oxygen Plant (MWe)	5.9
Oxidant Compressor (MWe)	7.1
Blowers (MWe)	0.04
Pumps (MWe)	0.06
Steam Plant Station Load (MWe)	1.5
Net System Power Output (MWe)	**59.6**
Plant Heat Rate (Btu/kWh)	10,990
Plant Efficiency (%)	**31.0**

The MHD System Retrofit Provides Higher Energy Efficiencies than Those Obtained in a Conventional Coal-Fired Plant

The "active control" power conditioning system is capable of controlling Faraday currents and Hall voltage profiles in the channel to values that maximize performance. This design enables use of a shorter channel, with resulting cost savings for both channel and magnet.

The heat recovery radiant furnace receives the hot gas from the diffuser. Preheated secondary air is added to a secondary combustor, achieving a stoichiometry of 1.05 to minimize NO_x emissions. Downstream heat recovery consists of the oxidant heater, steam superheaters, secondary air heater, economizer, and coal drying gas heater. The combustion gas exists the boiler at less than 360°F and enters the existing electrostatic precipitator, where flyash and spent seed are removed.

The MHD retrofit described above increases the net power of Unit Two from 48.5 MW to 59.6 MW. Unit efficiency is increased from 28 to 31 percent. An increase of 20 MW in coal thermal input (from 172 to 192 MW) is required, resulting in an incremental utilization efficiency of 55 percent, that is, increase in power out/increase in thermal power in.

THE PLANT ARRANGEMENT FOR THE MHD SYSTEM RETROFIT AT SCHOLZ GENERATING STATION CAN BE EASILY IMPLEMENTED.

Included are all subsystems, an MHD switchyard, an MHD ash disposal area, and an allocated space for an on-site seed regeneration plant, which was not designed in this study.

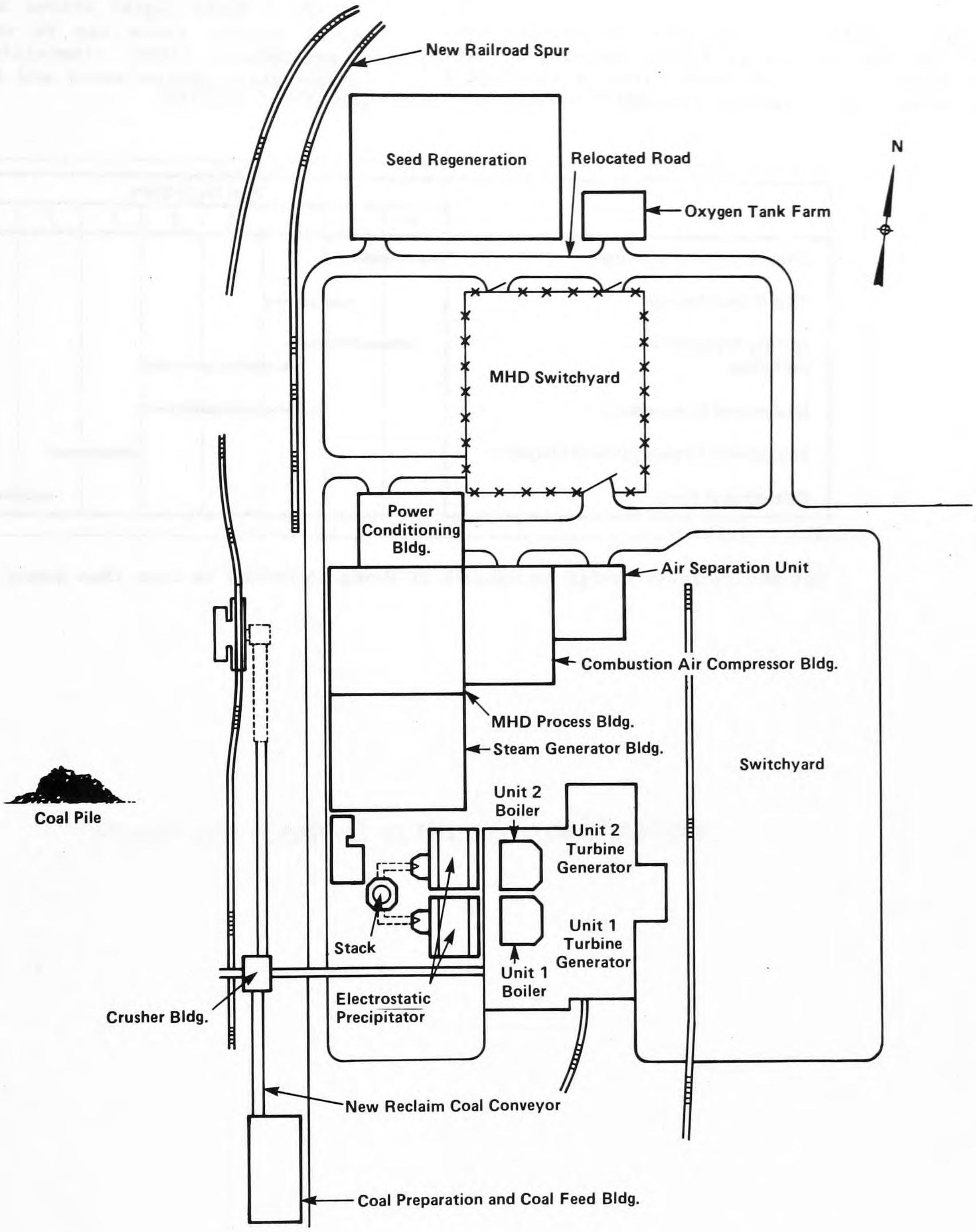
The steam generator can be located very close to the boiler and electrostatic precipitator. The steam, water, and exhaust gas interfaces are very short and easy to incorporate. A coal preparation building is located adjacent to the crusher building, and coal can readily be fed by a dense-phase pneumatic system.

DESIGN, CONSTRUCTION, AND TESTING OF THE MHD RETROFIT CAN BE ACCOMPLISHED IN A REASONABLE TIME FRAME.

With an overall time frame of 7.5 years, the first three years consist of the preliminary design (Title I) and final design (Title II) phases. Construction and installation of the facilities and equipment is completed by the sixth year and operational testing is completed in 7.5 years. This schedule assumes the fabrication of a new magnet, which is the pacing system for the entire project. If the ANL magnet is used, the overall schedule is shortened to 6.5 years.

Prior to initiation of a Title I preliminary design, several conceptual design and technology development activities need to be performed, including:

- Optimization of the generator design and performance.
- Steady-state and transient part-load evaluations.
- Development of a structural channel featuring high-bore utilization.
- Development of a fully active control power conditioning system.
- Integration of a seed regeneration system.
- Evaluation and incorporation of results from DOE proof-of-concept testing into the conceptual design.



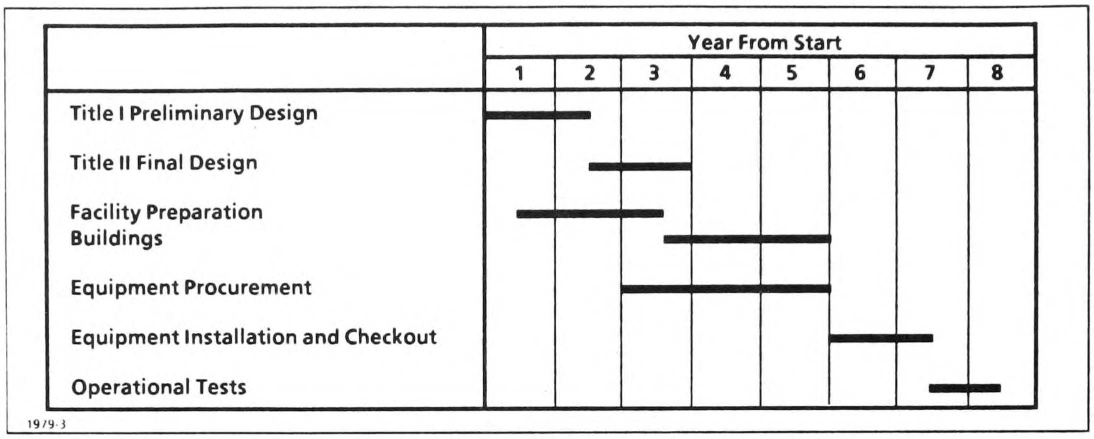
The Entire Envelope for the MHD Process System is Readily Accommodated at the Scholz Site

TOTAL PROJECT COSTS FOR THE MHD RETROFIT ARE REASONABLE.

The total initial cost estimate for design, construction, and testing is $186M, assuming on-site seed regeneration (a cost-effective) is added at a later date. Major elements include:

Engineering and Field Management.......$ 43M
MHD Systems...........................$115M
Facility Modifications and Interfaces..$ 28M

If the 6-Tesla magnet stored at ANL is used, the total project costs can be reduced by $18M, to approximately $168M. Installing an on-site seed regeneration system would add $22M to the project cost.



The MHD Retrofit Design is Capable of Being Installed in Less than Seven Years