Energy & Environmental Research Center

OPTIMIZING PERFORMANCE OF THE HESKETT STATION

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OPTIMIZING PERFORMANCE OF THE HESKETT STATION

ABSTRACT

The Montana–Dakota Utilities (MDU) Company's Unit 2 at the R.M. Heskett Station is a bubbling fluidized-bed combustor (FBC). This unit currently operates in the middle-to-low end of the dispatch curve and has marginal economics. This is due, in part, to the coal that is currently being burned. The FBC at the Heskett Station utilizes river sand as its bed material and has no back-end sulfur control. Therefore, to meet the current regulations for SO_2 control, the sulfur content in the coal must be low. Coal with an acceptable sulfur content is available from the Beulah mine and is currently being burned. While allowing the emission criteria to be met, this coal presents operational problems in the form of agglomeration of the bed material, which results in a shutdown approximately every 6 weeks to clean out the bed. These problems are related to the high sodium content in this fuel. Lower-sodium lignite is available from the Beulah mine and has been shown to reduce the problems associated with agglomeration; however, this coal has a higher sulfur content, and the current emission standards cannot be met with this coal.

In light of these problems, if the Heskett Station is to continue to burn the Beulah lignite, some operational change must be implemented. A switch of bed material from river sand to limestone is being proposed. The use of the limestone will allow the SO_2 emission standards to be met using the higher-sulfur, lower-sodium lignite. The lower sodium, coupled with the limestone, should greatly reduce the problems associated with agglomeration as indicated by other work performed at the Energy & Environmental Research Center (EERC) for the North Dakota Industrial Commission (NDIC) and MDU. Switching bed materials is expected to produce secondary benefits with respect to boiler efficiency by allowing the operation to follow load at optimal excess air levels while maintaining good fluidization qualities.

The purpose of the proposed work is to determine whether a switch to limestone will indeed allow MDU to continue to burn North Dakota lignite and to do so at an improved efficiency. A preliminary evaluation will be performed on a pilot-scale FBC at the EERC for selection of a limestone type and size, followed by a full-scale test burn at the Heskett Station. A 9-month program is proposed at a total project cost of $183,000. MDU is committing $55,000, of which $20,000 is cash and $35,000 are in-kind services in support of the test burn. A $55,000 match is being requested from the NDIC. The remaining $73,000 will be requested from the U.S. Department of Energy. If successful, this program will not only allow the Heskett Station to continue to use North Dakota lignite, but it should also allow MDU to improve its overall efficiency and move up on the dispatch curve.

OPTIMIZING PERFORMANCE OF THE HESKETT STATION

1.0 SUMMARY

The Montana–Dakota Utilities (MDU) Company's Unit 2 at the R.M. Heskett Station is a bubbling fluidized-bed combustor (FBC). This unit was designed to operate with river sand as bed material. This, coupled with the quality of the coal available from the Beulah mine has resulted in several operational problems that ultimately reduce the overall boiler efficiency and plant economics. Therefore, the unit currently operates in the middle-to-low end of the dispatch curve and has marginal economics. Because the FBC at the Heskett Station uses river sand as its bed material and has no back-end sulfur control, the current regulations for SO_2 control can be met only with lower-sulfur coal. Coal with an acceptable sulfur content is available from the Beulah mine and is currently being burned. While allowing the emission criteria to be met, this coal presents operational problems in the form of agglomeration of the bed material, which results in a shutdown approximately every 6 weeks to clean out the bed. These problems are related to the high sodium content in this fuel. Lower-sodium lignite is available from the Beulah mine and has been shown to reduce the problems associated with agglomeration; however, this coal has a higher sulfur content, and the current emission standards cannot be met with this coal.

Secondary problems are encountered in the FBC at the Heskett Station due primarily to the river sand bed material. Because of the size and density of the river sand, a relatively high fluidization velocity is required to maintain good fluidization. At lower-load conditions, operation at this "minimum" velocity forces operation at very high excess air levels, with flue gas oxygen levels running as high as 9%. In addition, this high velocity results in high unburned carbon in the fly ash because of carryover of unburned coal, and the low bed temperature (1250°F) results in a greatly reduced unit efficiency. Attempts are made to keep the velocity and excess air levels as low as possible; however, this has resulted in fluidization problems, leading to severe agglomeration of the bed. Adequate control of NO_x is another problem related to the operation at high excess air levels.

In light of these problems, if the Heskett Station is to continue to burn the Beulah lignite, some operational change must be implemented. A switch of bed material from river sand to limestone is proposed. The use of the limestone will allow the SO_2 emission standards to be met using the higher-sulfur, lower-sodium lignite. The lower sodium, coupled with the limestone, should greatly reduce the problems associated with agglomeration, as indicated by other work performed at the Energy & Environmental Research Center (EERC) for the North Dakota Industrial Commission (NDIC) and MDU. Switching bed materials is expected to produce secondary benefits with respect to boiler efficiency by allowing the operation to follow load at optimal excess air levels while maintaining good fluidization qualities. These benefits will be realized by the combined effects of the proper selection of limestone size and the lower density of limestone when compared to river sand.

The proposed work will consist of two phases. This first phase will involve testing several candidate limestones in one of the EERC's pilot-scale bubbling FBCs. Proper limestone selection is critical. Because the Heskett Station operates at a relatively high velocity at full load (12 ft/sec), a friable limestone would be expected to generate a significant quantity of fines and overload the fly ash removal systems. In addition, the particle size of the limestone will be important and should be such

that low load conditions can be met at reasonable excess air levels while maintaining good fluidization quality. Pilot-scale testing will allow these criteria to be evaluated at a relatively low cost compared to full scale. Once a limestone has been selected that appears to be the best candidate for replacing the bed material at the Heskett Station, a full-scale test burn will be performed. Testing will be performed over the entire load range and will include a longer-duration (30-day) test to quantify the expected improvements in agglomeration and deposition.

The expected benefits of changing from sand to limestone as the primary bed material that will be verified by the test burn are as follows:

- The higher-sulfur, lower-sodium lignite can be used while still meeting SO_2 regulations. The use of the lower-sodium lignite should also reduce the problems associated with agglomeration.

- MDU will be able to generate SO_2 credits. The current market price is approximately $90/ton of SO_2. Assuming a coal with 1.2% sulfur and an expected SO_2 reduction of 90%, the value of the SO_2 credits would approximate $40/hr at full load operation.

- The tendency to agglomerate, even with the higher-sodium fuel, will be reduced, and the bed turnover rate will also be substantially reduced. This would result in lower fresh bed makeup rates and less material for disposal.

- Boiler efficiency will be improved, especially at the lower-load conditions, by allowing the unit to be operated at lower velocities and higher bed temperatures during turndown.

- The unit will be able to operate at higher bed temperatures during full-load operation to facilitate better carbon burnout and increase boiler efficiency.

- NO_x will be controlled over the full-load range by the unit's operating closer to optimum conditions.

2.0 PROJECT DESCRIPTION

To determine the extent to which these benefits are realized and to allow a cost–benefit analysis to be performed, a full-scale test burn is recommended at the Heskett Station. The following section outlines the proposed test conditions and the rationale for each. Some pilot-scale tests are also recommended to help define the conditions for testing on the full scale.

2.1 Pilot-Scale Testing at the EERC

The EERC has excellent pilot-scale FBC equipment and many years of experience burning North Dakota lignite. Pilot-scale testing is recommended prior to implementing the full-scale test burn. The goal of the pilot-scale testing is to choose the best limestone for the full-scale testing. Limestone selection will be based on the following criteria:

- Limestone attrition and change in fly ash-to-bed drain ratio

- SO_2 emissions (credits to be generated)
- NO_X emissions (impact on NO_X – could be increased)
- Particulates (anticipated changes in electrostatic precipitator [ESP] performance)
- Agglomeration (anticipate reduction or elimination)
- Deposition (may not run long enough to evaluate)

Four 12-hr tests per limestone are planned according to the matrix in Table 1 below. Testing of these limestones will be evaluated. These tests will be performed on the EERC's 8- × 8-in. bubbling FBC. A description of this system can be found in Appendix A.

TABLE 1

Test Matrix for Pilot-Scale Limestone Screening Tests

Temperature, °F	Load	Oxygen, %	Velocity, ft/sec
1550	Full	3	12
1400	Three-quarters	4[1]	MDU[1]
1250	Half	9[1]	MDU
TBD[2]	Half	4	TBD

[1] Same velocity and O_2 concentration as used at Heskett for a similar load. The heat transfer will be changed to allow these conditions to be met.

[2] As required to obtain 4% O_2 at half load using the same heat transfer configuration used in the previous test.

During these tests, the flue gas will be sampled continuously for SO_2, NO_X, CO, CO_2, O_2, and N_2O. Batch samples of coal, bed material, cyclone ash, and baghouse ash will be collected and weighed from each test period. The following analyses will be performed on these samples:

- Coal: ultimate/proximate, x-ray fluorescence analysis (XRFA) on three samples
- Bed material: XRFA, loss-on-ignition, and carbonate
- Cyclone ash: XRFA, loss-on-ignition, and carbonate for each matrix point and resistivity for one full-load test

The impacts of operating parameters on test variables will be determined to allow full evaluation of a changeover to limestone. A mass balance will be performed to determine the fly ash-to-bed material ratio at each condition. Optimal conditions for SO_2 capture will be determined and the amount of credits estimated. The risk of agglomeration while using limestone will be assessed, as will NO_X, particulate emissions, and combustion efficiency.

2.2 Full-Scale Test Burn

The full-scale test burn is designed to evaluate the impact of replacing the sand bed with limestone. The selection and sizing of limestone for use in the full-scale testing will have been determined in the previous task using the pilot-scale equipment. The expected benefits of changing from sand to limestone as the primary bed material discussed in Section 1.0 will be verified by the test burn.

The EERC would assist MDU in several areas of the planning, performance, and analysis of a full-scale test burn. The areas are listed below.

- Assist in developing the test plan for the test burn at the Heskett Station will be provided. This will involve helping choose operating conditions for the burn. An important part of this effort will include a review of previous data from the Heskett Station and the EERC pilot plants to determine the baseline prior to adding the limestone. Existing data would be used to note changes in NO_x, SO_2, and particulate emissions, combustion efficiency, and other operating parameters without limestone, so that when the test burn is performed the differences due to the limestone can be separated from the other process variables. This will allow MDU to better quantify the changes that occur because of the switch to limestone and those that are a result of changing operating conditions or of previous design changes.

- Design a sample and analysis plan to ensure that once the test is completed, MDU will be able to generate the data required to make an informed decision. The EERC can also help collect and prepare the samples for analysis.

- Observe the test and assist in making "on-the-fly" changes to the test matrix based on the results that are being obtained during the test burn.

- Perform on-line extractive samples of ash and collect deposits on specially designed in situ probes to evaluate changes in convective fouling (optional).

- Analyze and interpret the data collected during the test burn. The data should be correlated graphically through simple models so that MDU can easily determine the impacts of switching to limestone and changing operating conditions on the overall performance of all major emission and operational parameters.

2.2.1 Test Burn Plan Outline

It is recommended that the available sources of limestone be screened at the pilot scale and the following tests at full scale be performed on one limestone. The proposed plan is outlined below with the rationale for each action discussed in more detail in Section 2.2.

1. <u>Review current operations</u> to establish a baseline for comparison purposes and to determine whether observed changes correlate with fuel switch or with other parameters.

2. <u>Turn over bed to a limestone bed and stabilize unit</u>. This operation will take approximately 4 days. The goals are to turn the bed over to limestone and to evaluate impact of increased fly ash on cyclone and ESP performance. The slow turnover should preclude any rapid upsets of the unit. Specific activities are listed below.

   a. Set bed drain rate to 50 tons/day. Initiate limestone feed rate at 50 tons/day. Operate for 4 days to allow the bed to turnover from sand to limestone. The actual limestone feed rate will need to be slightly higher than 50 tons/day to account for the loss in weight due to calcination. This feed rate can be adjusted to keep the bed pressure drop at the desired rate. The unit need not run a full load during the changeover.

b. Monitor changes in cyclone and ESP performance. Once per shift, or in whatever time frame is practical, perform a rough material balance to determine how much material is being removed by each device. Continuously monitor opacity to ensure we do not approach the emission limits.

c. Monitor the stability of the unit by looking at temperature profiles and the EERC agglomeration meter (discussed later).

d. Monitor SO_2 emissions.

e. Collect solid samples at least every 8 hours for off-line analysis at a later date. These samples may or may not be analyzed, depending upon how the transition to limestone goes.

f. Monitor ash buildup and sootblower effectiveness.

3. Begin recycle of spent bed material. The goal is to get the unit to steady state under the desired operating mode, that is with recycle, and to establish a balance between bed drain and fresh limestone makeup.

   a. After 4 days of operation, start to recycle the drained bed material.

   b. Add only as much fresh limestone as required to maintain bed height.

   c. Operate in this mode until the SO_2 concentration reaches a stable value. It should start out close to zero and increase as the limestone in the bed recycle becomes fully sulfated.

   d. If the steady-state SO_2 level is higher than the target level, increase the fresh limestone feed rate to bring the SO_2 to the targeted rate. (The target SO_2 can be set at compliance level or, if MDU wants to sell credits, at a low rate. The cost of limestone versus the price of credits will determine which is the most economically favorable).

4. Optimize operation of the unit at low load by varying the bed depth, temperature, and velocity. The goal of this set of tests is to determine the minimum velocity and maximum temperature the unit can operate at low-load conditions.

   a. Reduce load by one-half using standard operating procedures. Collect data for heat rate calculations.

   b. Lower velocity to a point equivalent to 6% O_2 in the flue gas. Collect data for heat rate calculations.

c. Lower velocity to an equivalent of 4% O_2 in the flue gas. Fluidization will need to be monitored. It may be necessary to experiment with one cell to determine how low the velocity can be reduced while still maintaining fluidization. Collect data for heat rate calculations.

d. At each of these conditions, reduce bed depth to lowest practical limits to maximize bed temperature.

5. Optimize performance at high load by varying bed temperature, bed depth, and overfire air (OFA). The goal of this set of tests would be to determine whether boiler efficiency can be increased by maximizing the bed temperature and optimizing OFA.

   a. Bring unit to full load under normal operating procedures. Collect data for heat rate calculation.

   b. Increase bed temperature to 1600°F. Collect data for heat rate calculation.

   c. Increase the amount of OFA (amount to be determined). Collect data for heat rate calculation. Observe changes in temperature distribution (heat flux) and in gas composition above the bed and at the stack.

   d. Increase the amount of OFA by a second increment. Collect data for heat rate calculation, observe changes in temperature distribution, and monitor gases.

   e. Perform OFA tests at a second temperature.

6. Optimize performance at middle load primarily by varying velocity, bed depth, and bed temperature. The goal of this set of tests is to determine whether the already efficient operation at middle loads can be increased. Conditions for testing will be selected based on performance from the low- and high-load tests.

   a. Bring unit to 60 MW under normal operating procedures. Collect data from heat rate calculation.

   b. Decrease velocity to obtain an O_2 concentration of 3%. Set OFA split to the optimum level from the high-load tests. Adjust bed height to maximize bed temperature. Collect data for heat rate calculation. Monitor changes in gas composition.

   c. Depending upon results, further testing at different velocities, bed depth/temperature, and/or OFA split may be warranted.

7. Perform a long-term recycle test to determine the impacts of limestone on long-term boiler performance. The goals of this task would be to better determine the relationship between fresh limestone add rate and SO_2 emissions for use in economic calculations, impacts of the limestone on deposition rates, and whether the steady-state sodium concentration will be maintained at a level low enough to eliminate agglomeration problems.

a. Operate the unit for 30 days with recycle of bed material and a makeup of fresh limestone at rates determined from the first set of tests.

b. Collect solid samples on a daily basis for sodium analysis.

c. Monitor rates of flow to cyclone and ESP and their collection efficiency.

d. Determine whether fouling of heat-transfer surfaces is occurring. This could be done by monitoring changes in steam temperature or the amount of attemperating spray required.

e. Observe bed drain for evidence of agglomeration.

Sampling and measurements to be taken during the test program include the following:

- Air flows

- O_2, SO_2, CO, and NO_X, at the stack for all tests and at the top of the bed and at the combustor exit for selected tests.

- Opacity

- Temperatures and heat flux above the bed and at the combustor outlet

- Fly ash and bed drain quantities and chemical analysis for loss on ignition, sodium and calcium, and carbonate

- Plenum pressure fluctuations as a measure of fluidization

Evaluation criteria utilized will include, to some extent, all of the following:

- Heat rate
- Temperature distributions
- CO, SO_2, and NO_x concentrations
- LOI of the fly ash
- Visual observation of the bed and fireball

2.2.2 Rationale for Selection of Full-Scale Test Parameters

Bed Turnover and Stabilization

The first task is to facilitate a changeover of the bed from sand to limestone. One option is to replace the entire bed with fresh limestone after a shutdown. This can cause operational problems, especially with limestone breakup and blow-over as the limestone first calcines and then starts to sulfate. Calcination will occur rapidly, producing a "lightweight" calcine. The limestone becomes heavier once it is sulfated. It takes a relatively long time to sulfate the bed, however, since sulfur is slowly introduced with the coal.

The recommended method of turning over the bed is, after the initial charge of sand, to replace the fresh sand feed with fresh limestone. This will allow the changeover to occur gradually and will allow any changes that occur to the system to occur at a slow enough rate that they can be monitored. Changing the bed from sand to limestone in this way will take several days, depending upon the drain rate of the spent bed and add rate of the fresh limestone. For example, it is calculated that at a bed drain rate and corresponding fresh limestone feed rate of 50 ton/day, 75% of the bed would be replaced with limestone after 3 days and 85% after 4 days. The changeover rate would be less if the spent bed material were recycled.

Fly Ash Distribution

The main change that is expected from the switchover to limestone is higher fly ash loadings in both the mechanical collectors and the ESP. Any limestone will be more friable than sand and result in more fly ash. Also, the limestone will be sized smaller than the sand so that the bed can be fluidized at lower velocities. By implementing a slow transition from sand to limestone, it can be determined whether increases in fly ash will become a problem and, if so, at what level of limestone to sand in the bed.

Because of the higher ash loadings, some changes in heat-transfer rates may be seen. Deposition rates on the heat-transfer surfaces are expected to change. Deposits may form at a faster rate, but should be much easier to remove with existing sootblowers. We should be able to see short-term effects during these tests, but not long-term effects.

Limestone Feed Rate - SO_2 Emissions

To optimize the add rate of limestone, it will be important to determine the level of fresh limestone required to get the desired SO_2 emission reductions. It is expected that at steady state, some of the limestone will break up and be carried out of the bed as fly ash. There is no intent to recover or recycle the fly ash. The bed drain, on the other hand, would be collected and recycled. Ideally, the amount of fresh limestone required to get the desired SO_2 reduction will be less than the amount lost in the fly ash. In this case, the control point for adding fresh limestone is to maintain bed inventory.

A more likely case is that more fresh limestone will need to be added than is removed as fly ash. In this case, the limestone feed rate will be set by the desired SO_2 removal, and some of the bed material drain will not be recycled. This is acceptable, since a small fraction of the bed material should not be recycled to serve as a purge to keep the sodium from building up too high.

The amount of fly ash generated will be a function of the limestone chosen, since some are much more friable than others. One of the primary purposes of the pilot-scale tests will be to find a limestone that has a low attrition index and is not very friable.

There will be two criteria for choosing the amount of fresh limestone to add based on economics. Limestone could be added at a rate to bring SO_2 into compliance and no lower. A second scenario is to bring SO_2 to a very low level and generate credits for sale. A trade-off between limestone cost and the price of credits will determine which is the best from a purely economic standpoint. From an operational standpoint, the optimal limestone add rate may favor one or the other, or the operations may be good over the entire range of SO_2 emissions, allowing MDU to choose an add rate based on bottom line.

Limestone Type and Feed Size

The critical parameters for limestone selection will be good physical strength and not easy to break up. This will be important for the operation scenario where the bed material is drained and recycled. If the limestone is too friable, it will leave the system as fly ash and could overload the mechanical dust collectors and ESP. A friable limestone would probably result in a higher add rate than a less friable one (a number of factors other than friability determine this). A friable limestone may not generate enough bed material to facilitate the drain-and-recycle mode of operation that was discussed for minimizing the limestone feed rate.

The size of the limestone selected for testing will be set to fall within a range that can easily be fluidized over the entire load range (velocity ranging from 6 to 12 ft/sec) while still being large enough not to dramatically increase carryover. The size will be calculated based on theory and verified in pilot-scale testing.

Low-Load Operation

Under the current mode of operation, the size of the sand dictates high velocities at low-load operation to ensure that fluidization is not lost. The consequences of this are high excess air (O_2 as high as 9%) and low bed temperature (as low as 1250°F), which result in low boiler efficiency and high NO_x. If the low-load conditions could be accomplished at reduced velocity, excess air levels and bed temperatures more closely approaching normal operation could be maintained. This would increase overall efficiency at the low loads and reduce NO_x. The desired change is, therefore, to select a bed material with a smaller particle size that can be fluidized at lower velocities. The interaction between bed height, velocity, and bed temperature would need to be optimized.

High-Load Performance

A review of the data from the Heskett Station indicates that the unit efficiency tops out at about 60 MW and decreases as load is further increased. The data show a significant increase in unburned carbon in the fly ash as the load increases from 60 to 80 MW. Assuming that this accounts for the loss in efficiency, then changes to improve carbon burnout should be investigated. The higher gas velocities at the higher load are undoubtedly carrying over more fine, unburned carbon. Higher temperatures typically favor better burnout; however, Heskett may already be fully realizing the benefits of higher temperatures. Increasing the OFA, which should decrease the bed velocity, should reduce the amount of carryover, assuming that the fines that are currently being carried over are not being introduced above the OFA ports. Increasing the bed depth, as a general rule, also improves carbon burnout, assuming good fluidization is maintained.

3.0 STANDARDS OF SUCCESS

Success of this program will be measured by MDU's ability to continue to burn Beulah lignite at the R.M. Heskett Station. The degree of success will be also measured by improvements in overall plant efficiency, increased run time between outages, generation of SO_2 credits for sale, and most importantly, by an increase in the overall profitability of the plant.

4.0 BACKGROUND

The EERC, with a long history in the evaluation of fuels and limestones for FBC, has established a test program with the specific goals of performing test burns to obtain information for the design of new units; to provide air and solid waste emission data for permitting; to evaluate the impact of switching fuel, bed material, or limestone type in an existing unit; and/or to investigate and resolve a particular operating problem. For each test, fuel and limestone are shipped to the EERC from the mine to supply the proposed or existing operating plant. To quantity the effect of FBC design and operating parameters and the effects of fuel and sorbent properties, a number of important performance variables are measured. Environmental performance is evaluated by measuring sorbent addition and utilization to achieve the desired SO_2 control; measuring NO_X, N_2O, and CO emissions; determining particulate collectability; and waste characterization. Evaluation of thermal performance is accomplished through measurement of combustion efficiency; heat flux; moisture, ash, and sorbent thermal losses; and fouling in the convective pass. Operational performance is qualitatively assessed by examining for fouling and deposition on heat-transfer surfaces, agglomerations or sintering of ash or bed material, changes in coal or ash particle size, and evidence of corrosion or erosion. Detailed reports are prepared that can be used to complete feasibility studies, to issue to vendors for bid specifications, or to use in obtaining environmental permits. The EERC has performed these types of tests for 12 different customers, including Northern States Power, Wisconsin Electric Power Company, Foster Wheeler Energy Corporation, and Burns & Roe.

In addition, in 1996 the EERC completed a 3-year project focused on determining the cause and recommending mitigating measures for deposition and agglomeration in fluid beds. One of the primary test coals for this work was lignite from the Beulah mine. The NDIC was a sponsor of this work. The EERC also performed extensive work in the early-to-mid 1980s for the U.S. Department of Energy (DOE), with one of the goals being to find operational solutions to the problems associated with bed agglomeration. Beulah lignite was also a primary fuel for this test work. The results from these two programs include an understanding of how the agglomeration occurs, the influence of operating conditions on agglomeration, and the use of bed material and sorbent selection as a method for mitigating agglomeration.

Because of this strong background and understanding of the use of North Dakota lignite in the fluid bed, MDU has involved the EERC in activities related to the Heskett Station since 1985. One of the first phases of the retrofit of the old stoker at the Heskett Station to a fluid bed was a test burn performed by Babcock & Wilcox (B&W) to develop design data and cost estimates. The EERC was hired by MDU to witness the test burns, review the results obtained from B&W, and provide input as to the ability of the then-proposed retrofit to meet MDU's goals. The EERC and MDU have continued to collaborate on the operation of the fluid bed.

The EERC has a long background in field testing and sampling. As early as the 1970s, the predecessor to the EERC, the Grand Forks Energy Technology Center, was active in field work. Field sampling has been performed to address slagging and fouling issues, coal burnout and boiler efficiency, wet scrubber chemistry, and air emissions. EERC clients include MDU, Northern States Power, and Otter Tail Power Company.

5.0 QUALIFICATIONS

The EERC is one of the world's leading coal research facilities. Since its founding in 1951, the EERC has conducted research, testing, and evaluation of coals and associated combustion and gasification technologies. FBC research was initiated in 1975. As a part of the EERC FBC program, performance of the fluid bed with respect to emissions control and operational performance have been evaluated for a wide variety of bed materials, sorbents, and fuels. Programs focused specifically on agglomeration, deposition, corrosion, and erosion have been performed. Recently, the EERC completed a major program funded in part by the NDIC where the mechanisms of deposition and agglomerating were identified and mitigating measures recommended. The scope of work for the proposed program is based partially upon results from that program. A listing of other EERC FBC projects, clients, and publications is provided in Appendix A.

Mr. Michael Mann will serve as the principal investigator and project manager for the project. Mr. Mann has been involved in FBC research since 1981 and has headed up the EERC FBC research group since 1985. In this role, he has developed research projects and test methods, served as shift engineer for the operation of the various experimental units, analyzed and interpreted run data, and reported results from most of the FBC-related work performed at the EERC. Mr. Mann was MDU's representative to the test burns performed by B&W. He has also been responsible for keeping current in new developments in FBC technology, which he accomplishes by maintaining close contact with vendors and users of FCB technology. The breadth of his FBC experience can most easily be seen by reviewing the list of publications presented in his resume (Appendix B).

6.0 VALUE TO NORTH DAKOTA

The 80-MW fluid bed at the Heskett Station currently utilizes North Dakota lignite. However, because of the emission and operational problems discussed in this proposal, MDU may not be able to justify continued use of this coal unless these problems can be minimized by switching to limestone bed material. Therefore, the value of the project to North Dakota is the continued use of Beulah lignite at the Heskett Station. The ultimate success of the project would result in an increased demand of power from the Heskett Station based on reduced electricity costs. In this case, the state not only prevents the loss of a lignite user but could see an increased usage.

From the standpoint of MDU, this project becomes increasingly important as deregulation of the electric industry forces utilities to improve their overall cost effectiveness and generate a low-cost product. Improved efficiencies and lower-cost operation will put the Heskett Station in a more competitive position as the impacts of deregulation become a reality.

7.0 MANAGEMENT

Mr. Mann will act as both the Project Manager and Principal Investigator for this project. He will coordinate his efforts closely with those of Mr. Alan Welte, manager of the Heskett Station. The pilot-scale testing at the EERC will be scheduled within 2 weeks of the contract award. Mr. Mann has direct access to the engineering and technical support personnel required for performing these tests. He will be responsible for ensuring the tests are performed on schedule and that the objectives of the project are met. In addition, the EERC quality control manager will be consulted to ensure a high-quality product is delivered from the pilot-scale efforts.

Once the project has been awarded, Mr. Mann will meet with plant personnel at the Heskett Station to review project goals and finalize the schedule for the full-scale test burn. The timing for the test burn will be a function of contract award date. Mr. Mann will coordinate any pretest preparation with Mr. Welte. Mr. Welte will be responsible for ordering the limestone for the test burn, based on the recommendation from the EERC pilot-test program. The EERC will work closely with Heskett personnel during the operation of the test burn and the subsequent data reduction and interpretation. This combined effort will ensure that MDU's goals are met.

8.0 TIMETABLE

The duration of this project is 9 months. During the first 3 months, the review of current operations and pilot-scale test burns would be completed. Based on results from these efforts, the plans for the test burn would be finalized. The test burn would be scheduled to be completed during the second 3-month period. A final report will be issued to MDU and the NDIC at the end of 9 months (see Table 2). If the results of the work are positive, it is likely that MDU will switch to limestone and implement the other operational changes recommended from this work prior to completion of the final report. MDU could potentially proceed from the test burn directly into operation with limestone as a best-case scenario.

TABLE 2

Project Schedule and Milestones

Task Description	Timing, months from project start
Review of Current Plant Status	3
Pilot-Plant Tests at the EERC	3
Test Burn at the Heskett Station	6
Final Report	9