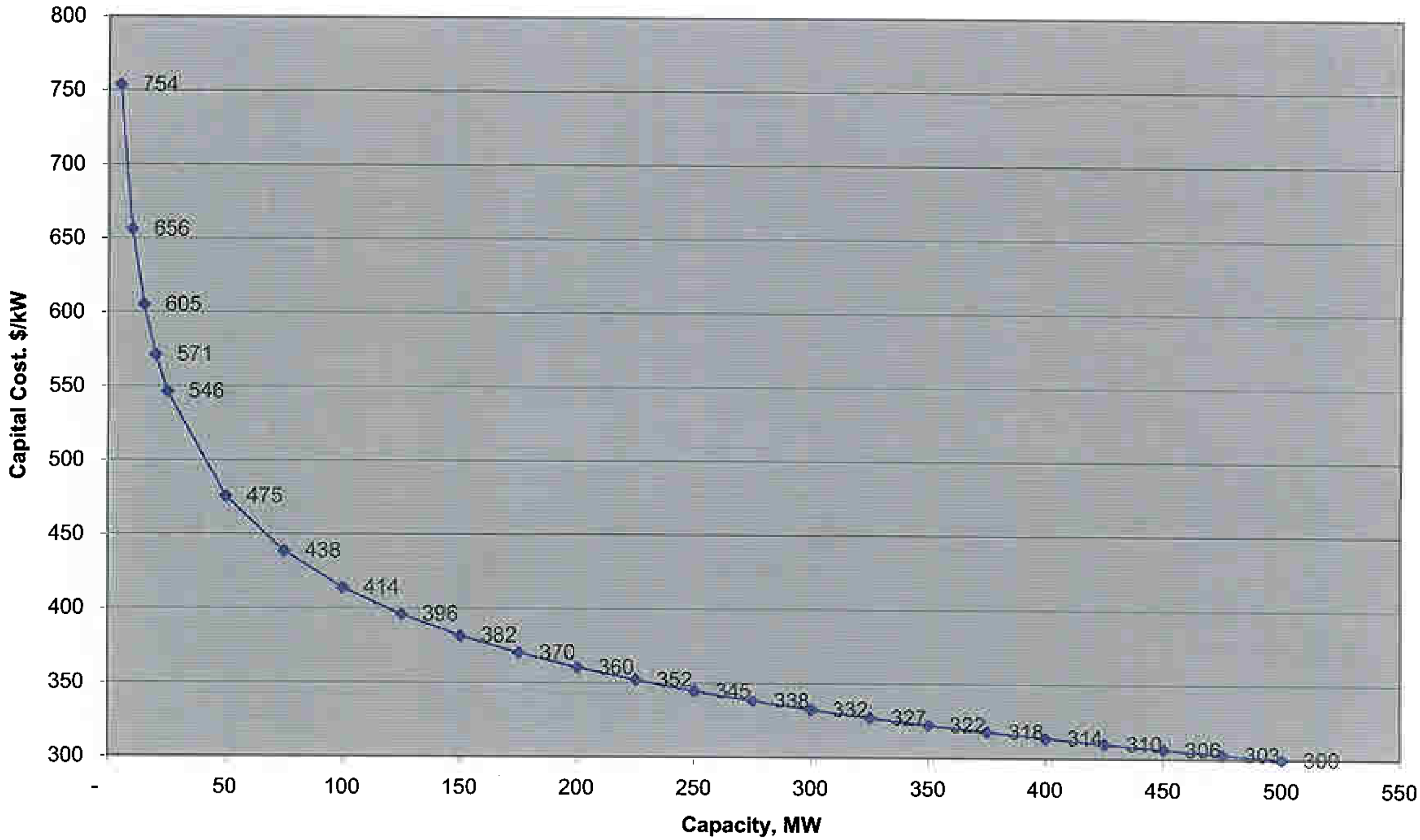
## Attachment 1
## Typical APC Equipment Cost per KW



# Attachment 2
# Proposed Selective Catalytic Reduction (SCR) for Healy Unit #1

Estimate of Capital and Operation & Maintenance (O&M) Costs

June 12, 2009

**Background:**
Golden Valley Electric Association (GVEA) is the owner and operator of Healy Unit #1, a 25-MW pulverized coal fired power plant in Healy Alaska. This plant is located within eight kilometers of Mt. McKinley National Park nearest boundary, in a Class 1 attainment area. In late 2008, GVEA contracted with CH2M-Hill to conduct a "Best Available Retrofit Technology" (BART) analysis to determine what technologies would be candidates to further reduce visibility impacting emissions from Healy Unit #1. With regards to nitrogen oxides (NOx), the CH2M-Hill reported that selective non-catalytic reduction (SNCR) and selective catalytic reduction (SCR) technologies would both be capable of reducing NOx emissions.

Healy Unit #1 currently uses Foster Wheeler lo-NOx burners with overfire air (OFA) to control NOx emissions. The burners and overfire air ports were installed in the summer of 1996. NOx emissions have generally averaged 0.28 lb NOx/mmbtu of coal fired over the last 13 years.

With a baseline of NOx emissions set at 0.28lbNOx/mmbtu, CH2M-Hill stated in their BART analysis that NOx emissions could be reduced to one-quarter the current baseline emissions with a properly designed SNCR system. Assuming the baseline emission is 0.28 lb NOx/mmbtu, a seventy-five percent reduction would equate to a new limit of 0.07 lbs NOx/mmbtu.. It should be noted CH2M-Hill did not consider spatial requirements for installing an SCR, specific to Healy Unit #1, in their BART analysis.

**Scope of Investigation:**
FuelTech is a consulting firm that specializes in SNCR and SCR applications. GVEA contacted FuelTech regarding the feasibility of retrofitting Healy Unit #1 with an SNCR and/or SCR system that would provide NOx reduction to meet the proposed 0.07lb NOx/mmbtu limit. On May 27, 2009, FuelTech conducted an on-site visit to assess if additional NOx reduction was feasible using SNCR-SCR technologies and to gather additional information to more fully assess the associated cost impact in order to meet the proposed 0.07lbNOx/mmbtu limit for Healy Unit #1.

**Results of the Investigation:**
FuelTech determined that it is feasible to retrofit Healy Unit #1 to meet the proposed 0.07lb NOx/mmbtu limit. However, the retrofit will require a dedicated SCR system. The SCR system proposed will use ammonia or possibly urea injection along with a two-layer catalyst. The injection equipment, catalyst, catalyst support steel, and all other equipment needed will be placed in a new stand-alone building, tentatively proposed to be located on the east side of the Unit #1 baghouse. New ductwork from the existing economizer outlet will be re-routed to the new building, and new ductwork will be installed to connect back into the existing flue gas system upstream of the air heater on the gas side.

The installation of a new SCR system in the existing flue gas system will create an additional pressure drop of 4.0 to 5.0 inches in water column. This additional pressure drop is outside the operating band of the existing induced draft (ID) fan, so a larger ID fan will be required to meet the new pressure requirements. In addition to a larger fan, a new ID fan motor will also be required. Due to the high negative pressure created between the SCR outlet and the inlet to the new ID fan, all ductwork, including all walls within the baghouse, will need to be mechanically strengthened to prevent collapse.

**Estimated Capital Costs for SCR Retrofit for Healy Unit #1:**

| | |
|---|---|
| 1. SCR system purchase | $13,300,000 |
| (installation, project management, misc) | 800,000 |
| 2. Relocation of Existing Unit #1 Equipment (in support of new SCR ducts into- out of power house) | 300,000 |
| 3. New ID fan and motor purchase | 700,000 |
| (installation, reconnect ducts, management, misc) | 450,000 |
| 4. New fan motor switchgear, installation, management | 400,000 |
| 5. Unit #1 Off-line for SCR Duct Tie-in | 1,917,406 |
| 6. Ductwork-Baghouse Support Stiffeners (includes material, installation, project management) | 350,000 |
| Capital Cost Estimate Total: | $18,217,406 |
| With 20% Contingency: | **$21,860,887** |
| Use: | $21.9 M |

**Estimated O& M Costs for SCR Retrofit for Healy Unit #1:**

(O & M costs include reagent, operations and maintenance expenses)

| | |
|---|---|
| 1. Assume 1.8 mils/kwh and 360 operating days per year: | $433,512 per year |
| 2. Catalyst replacement | 90,000 per year |
| 3. Cost of Replacing Lost Generation (Unit #1 output reduced; replaced with NP-GT's) | $414,131 per year |
| O&M Cost Estimate Total: | $937,643 per year |
| With 20% Contingency: | **$1,125,171 per year** |
| Use: | $1.2 M |

## HEALY UNIT #1 -- SCR ESTIMATE BACKUP

10-Jun-09

**Estimated Capital Costs for SCR Retrofit for Healy Unit #1:**

| | Source | Costs | Percent of Total Costs |
|---|---|---|---|
| 1. SCR system purchase (see note 1) | FuelTech | $13,300,000 | 73.01 |
| 1a. SCR system owner's costs (see note 2) | Flint Goodrich | $800,000 | 4.39 |
| 2. Relocation of Existing Unit #1 Equipment (see note 3) | Flint Goodrich | $300,000 | 1.65 |
| 3. New ID fan and motor purchase (see note 4) | Stan McHugh | $700,000 | 3.84 |
| 3 a. ID Fan owner's costs (see note 5) | Flint Goodrich | $450,000 | 2.47 |
| 4. New fan motor switchgear (see note 6) | Flint Goodrich | $400,000 | 2.20 |
| 5. Unit #1 Off-line for SCR Duct Tie-in (see note 7) | Kate Lamal | $1,917,406 | 10.53 |
| 6. Ductwork-Baghouse Support Stiffeners (see note 8) (includes material, installation, project management) | Flint Goodrich | $350,000 | 1.92 |
| Capital Cost Estimate Total: | | $18,217,406 | 100.00 |
| Contingency: 20 % | | **$21,860,887** | |

**Estimated O& M Annual Costs for SCR Retrofit for Healy Unit #1:**

(O & M costs include reagent, operations and maintenance expenses)

| | Source | Costs | Percent of Total Costs |
|---|---|---|---|
| 1. Assume 1.8 mils/kwh and 360 operating days per year: (see note "A") | FuelTech | $433,512 | 46.23 |
| 2. Catalyst replacement (see note "B") | FuelTech | $90,000 | 9.60 |
| 3. Cost of Replacing Lost Generation (see note "C") (Unit #1 output reduced; replaced with NP-GT's) | Kate Lamal | $414,131 | 44.17 |
| O&M Cost Estimate Total: | | $937,643 | 100.00 |
| Contingency: 20 % | | **$1,125,171** | |

### CAPITAL COST NOTES

Note 1: **"SCR system purchase"** includes:
preliminary studies, detailed engineering, civil-foundation, I&C, electrical system modifications, BOP mechanical work, support steel including access, SCR system, SCR ductwork, catalyst, reagent system, demolition, building enclosure

Note 2: **"SCR system owner's costs"** includes:
project management, engineering support costs, startup costs, project financing, code compliance, consumables, construction management

Note 3: **"Relocation of Existing Unit #1 Equipment"** includes:
feasibility, engineering, construction-relocation costs, demolition costs for providing pathways inside Unit #1 for SCR supply and return ducts

Note 4: **"New ID fan and motor purchase"** includes:
new ID fan, new ID fan motor

Note 5: **"ID Fan owner's costs"** includes
engineering, fan and motor foundation modifications, fan inlet and outlet ductwork modifications, relocation of existing equipment, control system tie-in with interlocks, fan testing and balancing, project management, unknowns

Note 6 **"New fan motor switchgear"** includes:
The existing switchgear is undersized for providing power to a new 1500 HP fan motor. Line item includes project management, engineering, construction and testing for new switchgear, relays.

Note 7 **"Unit #1 Off-line for SCR Duct Tie-in"** defined as:
**Unit #1 is expected to be off-line for 60 days to complete SCR duct tie-in to existing flue gas system. Assume Unit #1 loss of output covered by NP generating plant. Assumed current Unit #1 fuel/variable cost = $47.28/MWH and current NP Fuel/variable cost= $101.17/MWH. Difference is $53.89/MWH. Assume Unit #1 to produce 593 MWh/day. Therefore, cost of Unit #1 off-line, supplemented with power from NP generating station to be: (60 days)(593 MWh/day)($53.89/MWh) = $1,917,406**

Note 8: **"Ductwork-Baghouse Support Stiffeners"** includes
project management, engineering, materials and construction labor to install stiffener and support bracing on all flat surfaces subject to high negative pressure from SCR outlet duct to inlet of new ID fan, including entire baghouse structure

### O & M COST NOTES

Note A **"Assume 1.8 mils/kwh and 360 operating days per year"** means reagent at $450/ton delivered, system inspection, catalyst cleaning, and shift operations (defined as 1-manhour per shift)
*Calculated as: 669 MWh per day average (669,000 kwh/day* $0.0018* 360 = $433,500 per year)*

Note B **"Catalyst replacement"**
means a single layer will need to be replaced every two years at a cost of $160,000, with $20,000 added for shipping to Alaska. The annual average cost is $90,000 per year.

Note C **"Cost of Replacing Lost Generation"**
Fan motor to increase from 900 HP to 1500 HP due to SCR installation. Difference of 600 HP. (1 HP = 0.7457 kW) Therefore, 600 HP = 0.447 MW to be covered by firm capacity and energy at NP generating total cost of $107.23/MWh
(0.447 MW)(24 hr/day)(360 days/yr)($107.34 MWH @ NP) = **$414,131** per year

# Golden Valley Electric Association
# Healy Station
# Unit 1

# Conceptual Application of Selective Catalytic Reduction (SCR) Technology

**Prepared by:**

**Fuel Tech, Inc.**
**Warrenville, Illinois**
**June, 2009**

**Golden Valley Electric Association**
**Healy Station**
**Unit 1**

**Conceptual Application of Selective Catalytic Reduction (SCR) Technology**

## Summary

Fuel Tech, Inc. visited the Healy Station on 27 May, 2009 to assess the potential for Selective Catalytic Reduction (SCR) technology retrofit to Unit 1. SCR technology could be applied as a stand-alone NOx reduction technology or in combination with primary NOx control measures and Selective Non-Catalytic Reduction (SNCR) technology.

Baseline NOx emissions from Unit 1 are 0.28 lb/MMBtu. Golden Valley Electric Association (GVEA) is currently in discussions with regulatory agencies and a definitive NOx emission limit has not been decided, at this time. For the purposes of this conceptual analysis, 0.07 lb/MMBtu NOx emissions limit has been selected.

SCR technology can be feasibly applied to Unit 1. However, there are several unit-specific challenges that need to be resolved. More detailed study is required to determine the extent of these challenges, practical solutions and specific costs.

As a result of the Fuel Tech visit, GVEA requested Fuel Tech's opinion pertaining to retrofit costs for SCR at the station. This report summarizes the potential cost, assumptions, scope and exclusions.

## Basis of Analysis

Fuel Tech's analysis of the SCR retrofit is based principally on the site survey conducted on 27 May and the information we received at that time. Fuel Tech has not conducted a detailed engineering study in preparing this summary. Fuel Tech's opinion of the potential retrofit and estimated costs to GVEA is based on our experience with many SCR projects on coal-fired plants internationally. We have used recent cost estimates conducted by Fuel Tech to provide a high level price to GVEA.

As discussed during the site visit, SCR technology has not been retrofit to coal-fired units as small as these in the United States. Thus, Fuel Tech believes that "rule of thumb" and "interpolated specific prices", such as $/kW, would understate the actual costs. The size of the units affects the variance in these indicative cost measures, especially for units that are off of the scale for current industry experience.

Fuel Tech compared the estimated SCR size and location for Unit 1 to recent SCR projects for which it was reasonable to estimate costs. We assessed fourteen (14) major scope groups on an installed basis and adjusted our estimate for Healy Station to account for site specific requirements.

These groups are:

1. Preliminary Studies
2. Detailed Engineering
3. Civil Works and Foundations
4. Instrumentation and Control
5. Electrical System Modifications
6. Balance of Plant Mechanical Work
7. Support Steel including access
8. SCR Reactor System
9. Flue Gas System (ductwork, dampers, expansion joints)
10. SCR Catalyst
11. Reagent System (storage, housing, delivery)
12. Demolition
13. Enclosures
14. Installation

Fuel Tech assumed the following conditions and issues:

First, the SCR reactor would be placed outside the existing boiler house for Unit 1. There are advantages to an outside location:

- Support steel and foundations can be designed without impacts to the existing structures;
- Significant boiler modifications can be avoided;
- Relocation of existing piping, conduit and equipment can be minimized;
- Proper SCR reactor size can be designed and installed with less complexity
- Cost estimates are more easily determined since scope can be better defined

Fuel Tech considered an SCR system that would be more integral to the existing boiler structure, and this approach would remain a possibility. It should be studied in a more detailed feasibility report. The specific challenges pertaining to Unit 1:

- duct expansion within the existing buildings;
- transitions in and out of the SCR reactor;
- relocation of existing equipment;
- structural support and foundations within the boiler enclosures.

For this analysis, Fuel Tech assumed that there would be little difference in estimated costs between the two approaches, given the accuracy of the estimate requested by GVEA.
Industry experience has shown, however, that free-standing SCR systems are typically less costly than those integrated into existing structures.

Second, the proper SCR operating temperature range can be reasonably controlled for optimal catalyst performance. We note that current or expected flue gas temperatures may be higher than preferred, but that a solution can be engineered without significant impact to the unit.

Third, the SCR systems would be fully enclosed.

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**Full Scale SCR Description**

The following table presents a comparison of the conceptual SCR systems for the Healy Station:

| | **Unit 1** |
|---|---|
| Flue Gas Flow (acfm) | 171,200 |
| Flue Gas Temperature (F) | 700 - 750 |
| Inlet NOx Loading (lb/MMBtu) | 0.28 |
| NOx Reduction Efficiency (%) | 75% |
| Initial Operating Period | 16,000 hours |
| Design Ammonia slip (ppmvd) | 2 |
| # Installed Catalyst Layers | 2 + 1 (spare) |
| Estimated Catalyst Weight (tons) | 40 |
| Reactor Plan Area (sq ft) | 240 |

The Fuel Tech estimate is based on locating the SCR reactor outside the existing boiler enclosure on Unit 1. New flue gas ducts would direct flue gas from inside the boiler enclosure to the new reactor and then transition back into the heat recovery section of the boiler.

For Unit 1, the location is on the east side of the unit outside the warehouse access and adjacent to the fabric filter enclosure.

## SCR Estimated Costs

Fuel Tech estimates the capital cost for the conceptual SCR systems, as described in this summary, to be:

Unit 1: $13,300,000

This cost is conservative, and subject to change due to scope additions and the exclusions noted below. A detailed Engineering study and Cost Analysis are required to provide a more definitive estimate.

### Operating & Maintenance Expenses

Estimated operating and maintenance expenses are summarized in the following table.

| Item | Value | Unit 1 |
|---|---|---|
| **Draft Loss** | **in w.g.** | **4 – 5** |
| **Station Service** | **kWh** | **Note 1** |
| **O & M** | **Mils / kWh** | **1.8** |
| Reagent | Note 2 | |
| System Inspection | | |
| Catalyst Cleaning | | |
| Shift Operations | Note 3 | |
| **Catalyst replacement** | **Note 4** | **$160,000** |

Note 1: Assumes power consumption from motors and heaters is low and included in ordinary station service. Detailed analysis is needed.
Note 2: Based on $450/ton of equivalent $NH_3$ cost. Fuel Tech recommends GVEA research possible $NH_3$ or urea suppliers for the Healy Station.
Note 3: Based on one (1) manhour per shift.
Note 4: Based on $8,000 per cubic meter of catalyst per layer. One layer exchanged every two (2) years.

### Exclusions

Fuel Tech has excluded the following items from consideration in these estimates. GVEA must factor these into its final cost estimate.

1. Owner's Costs
   a. Project Management
   b. Engineering
   c. Supervision
   d. AFUDC & Financing
2. New ID Fans
   a. Upgrades to plant electrical system
3. Potential Equipment Relocation
4. Duct Stiffening and other boiler modifications as required per NFPA Codes

## Recommendations

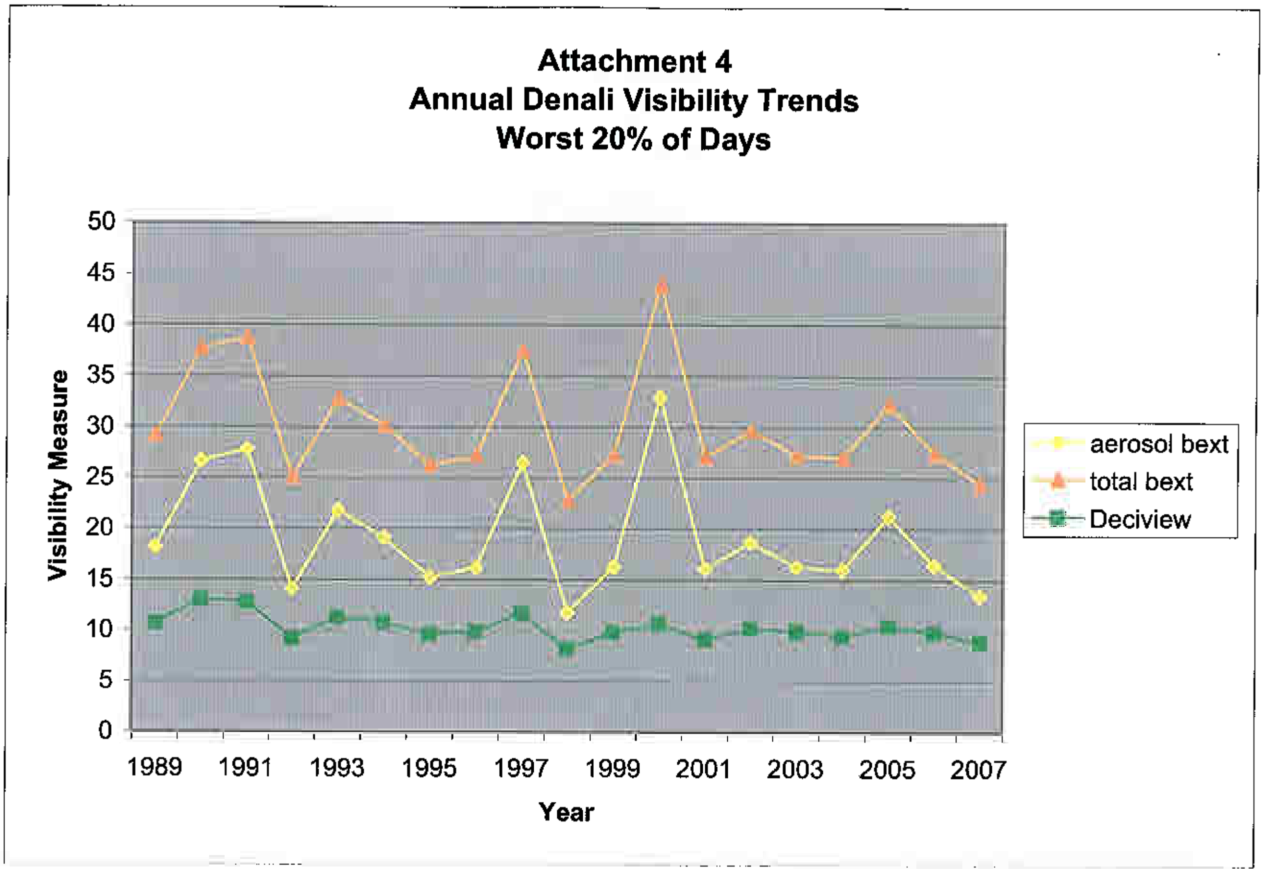
Fuel Tech recommends:

1. GVEA contract for a detailed Engineering study to evaluate potential SCR options including: location, balance of plant modifications, service requirements, capital cost, and long term projected Operating and Maintenance expenses;
2. GVEA consider alternative approaches, such as combined technologies, to determine better cost/benefit value to GVEA.

Attachment 3

# ECONOMIC ANALYSIS SUMMARY

| Healy Unit 1 | Boiler Design: | Wall Fired | Wall Fired |
|---|---|---|---|
| Parameter | Current Operation | NOx Control SCR | NOx Control SCR |
| **Case** | 1 | **15 year life** | **8 year life** |
| NOx Emission Control System | LNB w/OFA | SCR | SCR |
| ***TOTAL INSTALLED CAPITAL COST ($)*** | **0** | **21,860,887** | **21,860,887** |
| ***FIRST YEAR O&M COST ($)*** | | | |
| **TOTAL FIXED O&M COST** | **0** | **1,125,172** | **1,125,172** |
| Reagent Cost | 0 | 79,292 | 97,519 |
| SCR Catalyst | 0 | 90,000 | 110,689 |
| **TOTAL VARIABLE O&M COST** | **0** | **169,292** | **208,208** |
| **TOTAL FIRST YEAR O&M COST** | **0** | **1,294,464** | **1,333,380** |
| | | | |
| ***FIRST YEAR DEBT SERVICE ($)*** | 0 | 2,553,998 | 4,678,584 |
| ***TOTAL FIRST YEAR COST ($)*** | **0** | **3,848,461** | **6,270,611** |
| ***CONTROL COST ($/Ton Removed)*** | | | |
| **NOx Removal Rate (%)** | **0.0%** | **75.0%** | **75.0%** |
| **NOx Removed (Tons/Yr)** | **0** | **310** | **310** |
| **First Year Average Control Cost ($/Ton NOx Rem.)** | **0** | **12,397** | **20,200** |
| ***PRESENT WORTH COST ($)*** | **0** | **31,021,252** | **34,262,852** |



Attachment 4
Annual Denali Visibility Trends
Worst 20% of Days
Visibility Measure
50
45
40
35
30
25
20
15
10
5
0
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
Year
aerosol bext
total bext
Deciview