INSTITUTE FOR ENERGY STUDIES
THE UNIVERSITY OF NORTH DAKOTA

Evaluation of Carbon Dioxide Capture From Existing Coal Fired Plants by Hybrid Sorption Using Solid Sorbents

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Presentation Overview

- Project team
- Background on the proposed technology
- Project objectives
- Technical approach/project scope
- Project organization
- Project budget
- Project schedule
- Risk management

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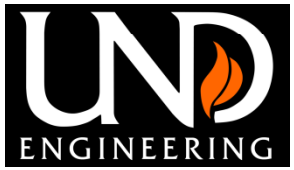
Project Team

- US Department of Energy - NETL
- UND Institute for Energy Studies
- Envergex LLC
- Lignite Energy Council
- ALLETE Group
  - Minnesota Power
  - BNI Coal
- SaskPower
- Burns & McDonnell
- Solex Thermal



Background on the proposed technology and its scientific/technical merit

Background on the proposed technology and its scientific/technical merit

- The hybrid sorption CACHYS process uses a regenerable metal carbonate-based sorbent for CO_2 capture

- Initial testing of the concepts was conducted as part of a DOE-STTR project conducted by Envergex and UND

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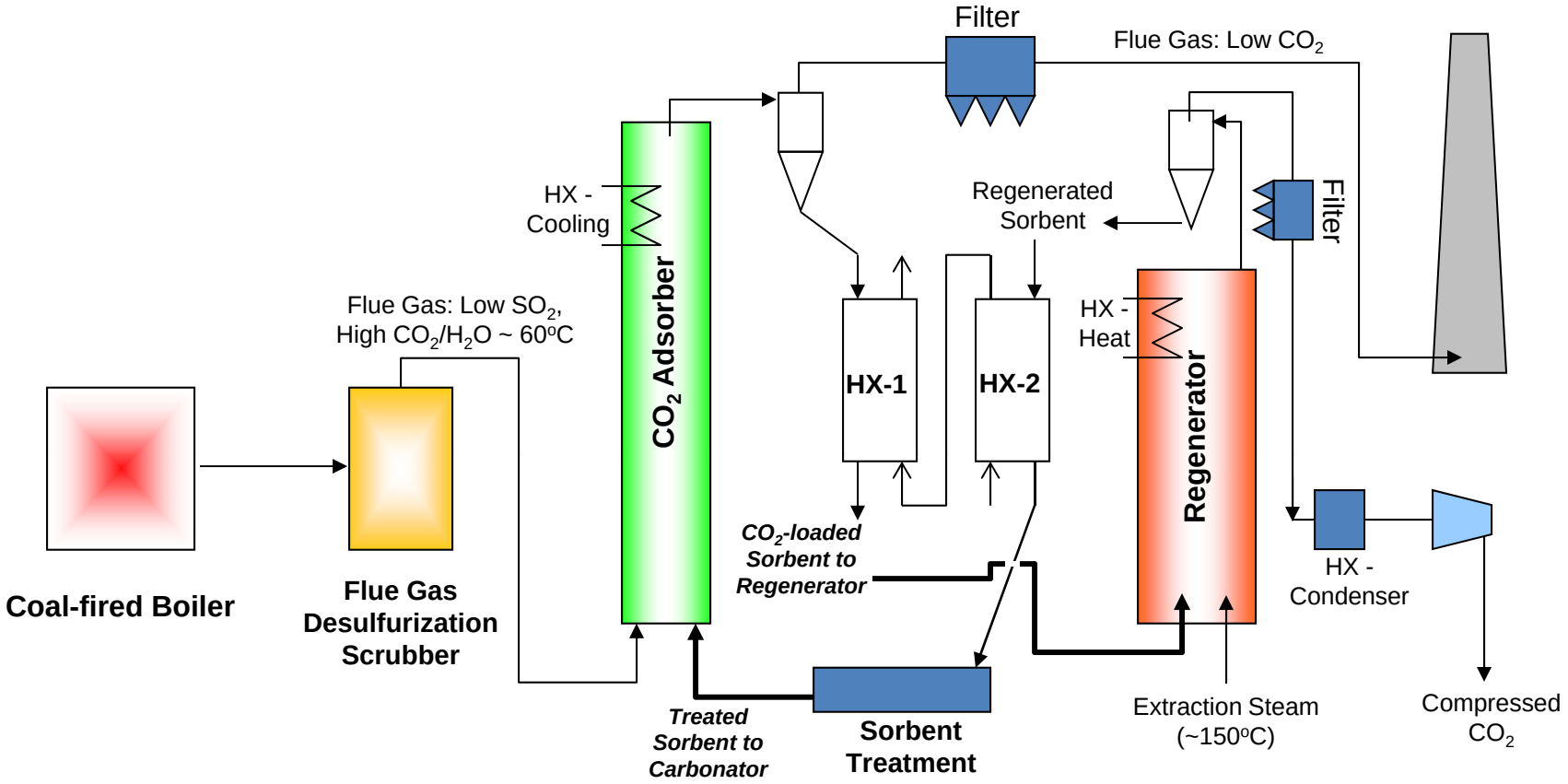
CACHYS™ Hybrid Sorption Process



- Sorbents prepared from bulk materials – low cost target
- Key component – metal carbonate salt
- Reacts with CO_2 to form adduct. Reversible with the addition of heat
- Additive - enhances adsorption kinetics and reduces regeneration energy

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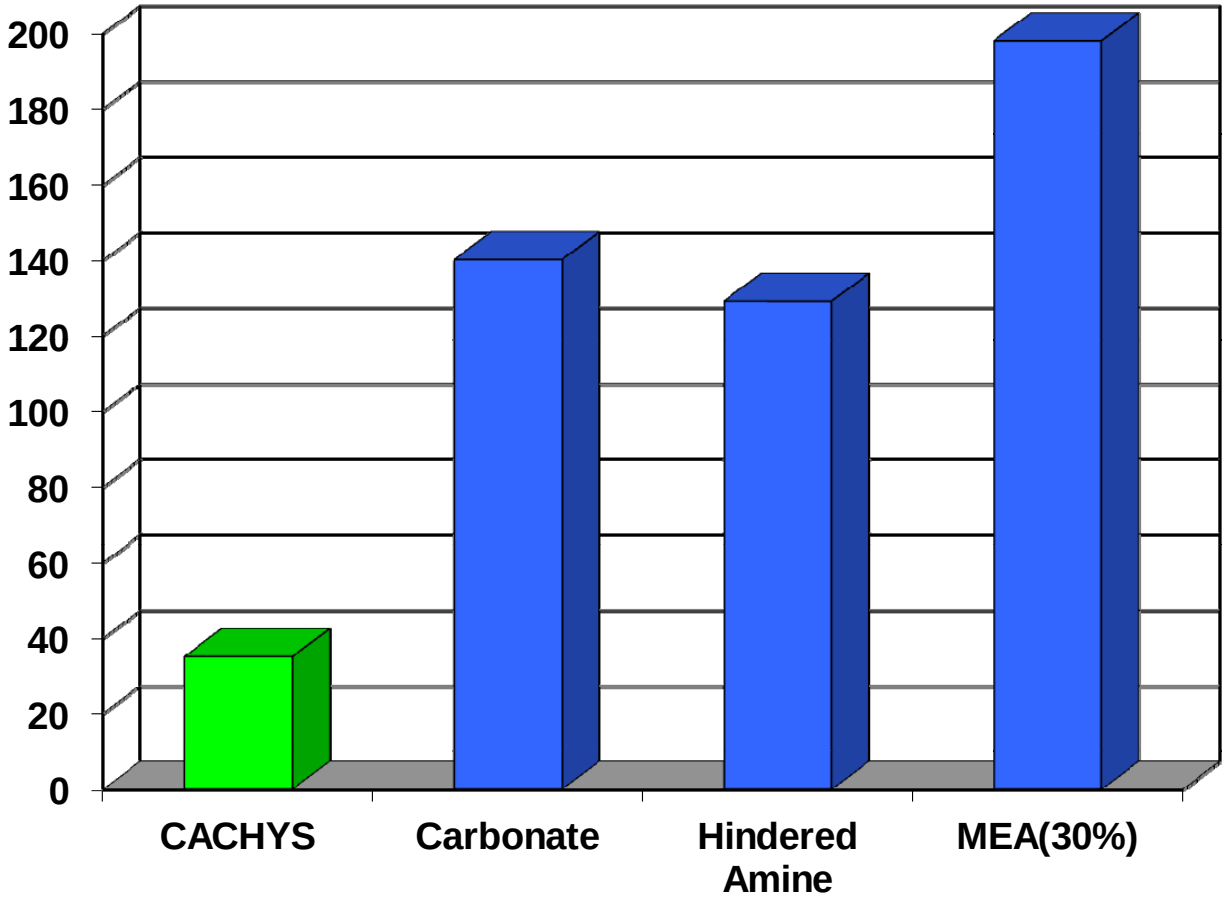
CACHYS™ Process Benefits

- ✓ Low heat of reaction observed ~ 40 kJ/mole CO_2
- ✓ High sorbent capacity
- ✓ Increased sorption kinetics
- ✓ Use of low cost, abundantly available materials
- ✓ Target is to exceed DOE's goal of 90% CO_2 capture at less than 35% increase in cost of electricity



Heat of Reaction (kJ/mole CO_2)

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Project Objectives/Technical Approach and Project Scope

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Project Objectives

- Develop a process that will efficiently capture CO_2 from flue gas streams and regenerate into a pure CO_2 stream, with a lower operating cost than current methods
- Goal: 90 percent CO_2 removal at no more than 35 percent increase in the cost of electricity
- Combine existing technologies to create a new sorbent which will have high CO_2 loading capacity and a process with low regeneration energy penalty

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Technical Approach and Project Scope

- Scope of work includes eight main tasks:
  - Task 1: Project Management and Planning
  - Task 2: Initial Technology and Economic Feasibility Study
  - Task 3: Determination of Hybrid Sorbent Performance Metrics
  - Task 4: Bench-Scale Process Design
  - Task 5: Bench-Scale Process Procurement and Construction
  - Task 6: Initial Operation of the Bench-Scale Unit
  - Task 7: Bench-Scale Process Testing
  - Task 8: Final Process Assessment

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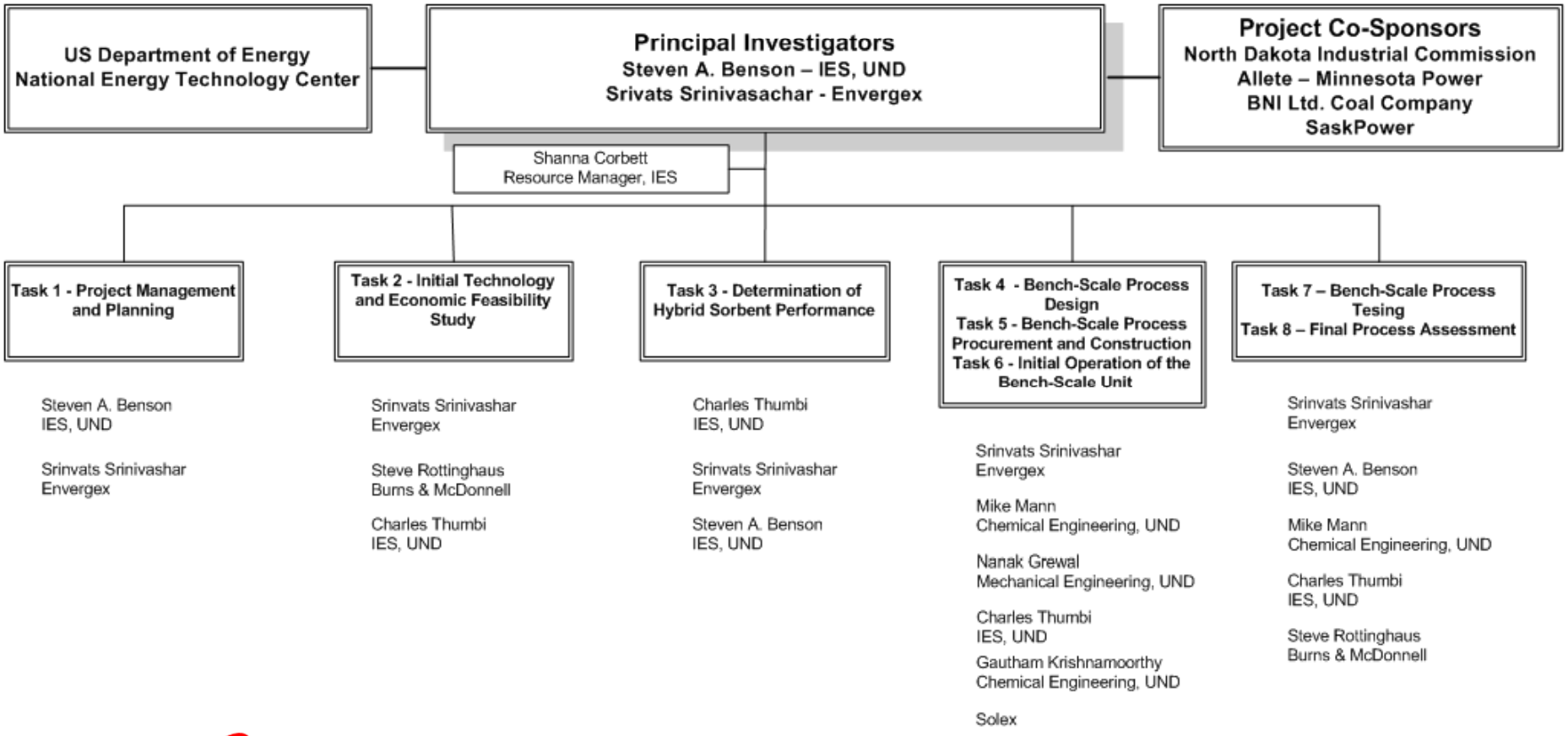
Project Organization

Organization Chart



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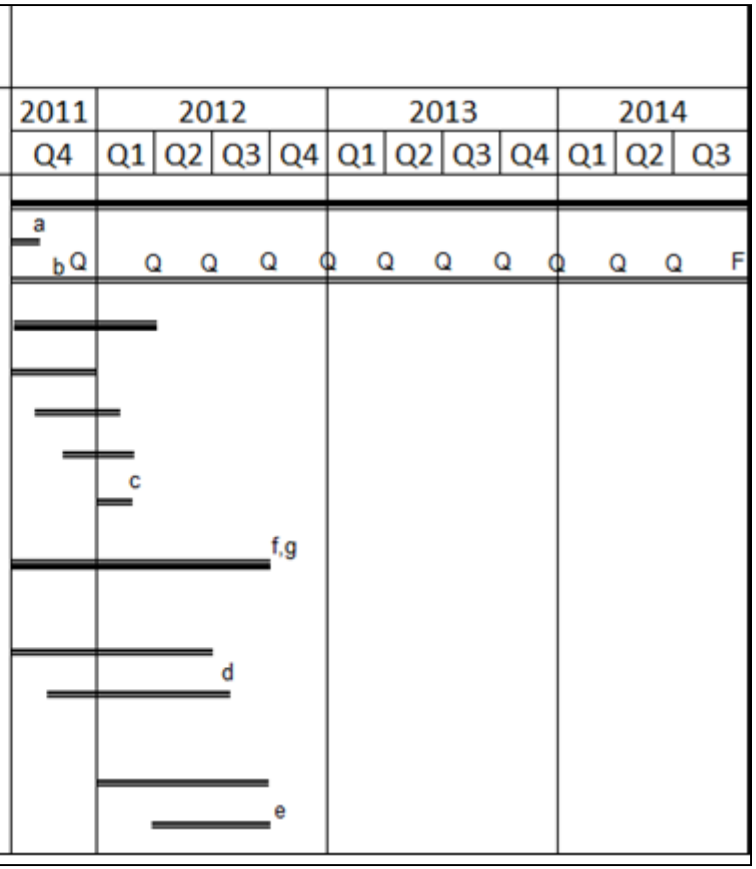
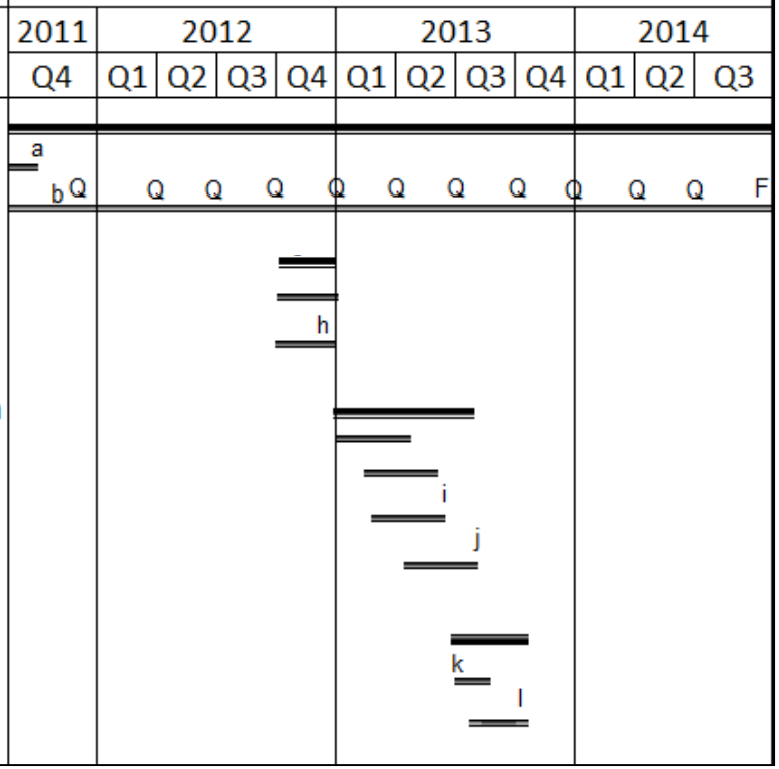
Schedule – Budget Period 1

1	TASK/ SUBTASK	TASK DESCRIPTION
1, 2, 3	**1**	**Project Management Plan**
	1.1	Project Management and Planning
	1.2	Briefings and Reports
1	**2**	**Initial Technology and Economic Feasibility Study**
	2.1	Detailed Process Description
	2.2	Process Modeling and Equipment Design
	2.3	Equipment Design
	2.4	Preliminary Technical and Economic Analysis
1	**3**	**Determination of Hybrid Sorbent Performance Metrics**
	3.1	Sorbent Formulation and Selection
	3.2	Bench-scale Testing of Sorbents
	3.3	Determiniation of Sorbent Physical Properties
	3.4	Fixed-Bed Reactor Testing



Schedule – Budget Period 2

	TASK/ SUBTASK	TASK DESCRIPTION
1, 2, 3	**1**	**Project Management Plan**
	1.1	Project Management and Planning
	1.2	Briefings and Reports
2	**4**	**Bench-Scale Process Design**
	4.1	Bench-Scale Adsorber Design
	4.2	Bench-Scale Regenerator Design
2	**5**	**Bench-Scale Process Procurement and Construction**
	5.1	Bench-Scale Process Procurement
	5.2	Bench-Scale Adsorber Construction
	5.3	Bench-Scale Regenerator Construction
	5.4	Bench-Scale Process Installation and Integration
2	**6**	**Initial Operation of the Bench-Scale Unit**
	6.1	Bench-Scale Shakedown Testing
	6.2	Bench-Scale Process Optimization



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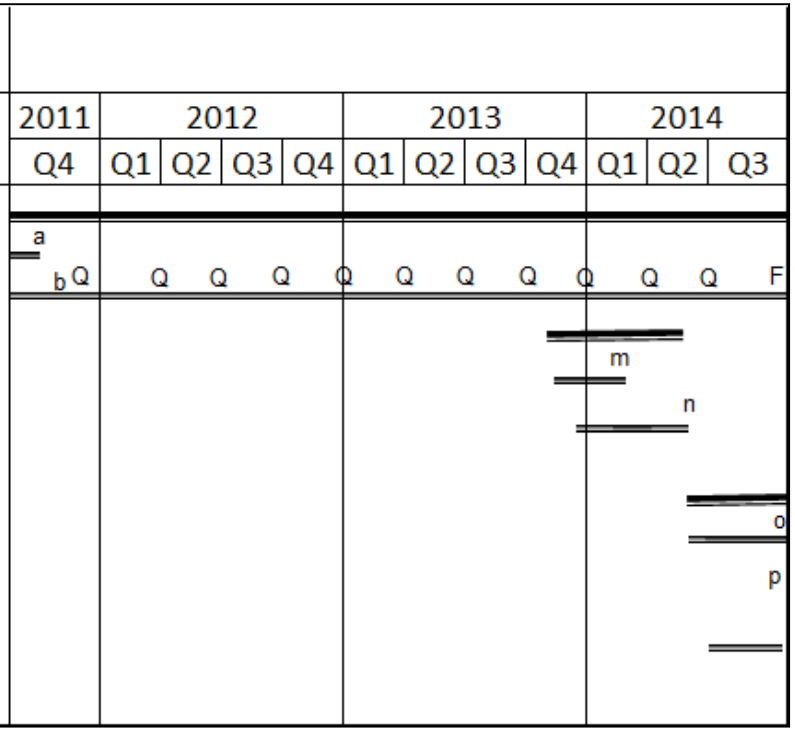
Schedule – Budget Period 3

-	TASK/ SUBTASK	TASK DESCRIPTION
1, 2, 3	**1**	**Project Management Plan**
	1.1	Project Management and Planning
	1.2	Briefings and Reports
3	**7**	**Bench-Scale Process Testing**
	7.1	Bench-Scale Parametric Testing
	7.2	Bench-Scale Continuous Testing
3	**8**	**Final Process Assessment**
		Process Environmental Health and Safety
	8.1	Assessement
	8.2	Final Technical and Economic Feasibility Study



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Risk Management

Risk Management Approach

- Project team will continuously evaluate the project for risks – Technical, Resource, Management
- All identified risks will be evaluated and measures to treat or manage will be determined and implemented.

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Initial Risk Register

Description of Risk	Probability (Low, Moderate, High)	Impact (Low, Moderate, High)	Risk Management (Mitigation and Response Strategies)
Technical Risks:			
Sorbent attrition	Moderate	Moderate	Change operating conditions, change sorbent formulation
Sorbent poisoning	Moderate	Low	Increase removal of SO_2; Additive to reduce poisoning
Process integration	Moderate	Moderate	Develop integrated process controls
Sorbent handling	High	High	Alternate sorbent formulation and equipment design
Sorbent agglomeration	Moderate	High	Use of diluents such as sand to reduce bonding
Resource Risks:			
Equipment Costs	Moderate	Moderate	Examination of alternative equipment resources
Continuous flue gas source – UND Steam plant	Low	High	Install on unit that has highest past availability
Personnel Availability	Low	Moderate	Utilize UND's wide expertise of personnel resources
Management Risks:			
Communication	Low	High	Coordinate and schedule meetings
Cost tracking	Low	High	Assign responsibility for managing cost; Utilization of project cost tracking system
Scheduling/meeting milestones	Low	High	Planning system and communication implementation

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