

“Carbon Capture & Utilization Using "VCCSTM Cycle" Technology - Phase I: Mineralization of Acidic Flue Gas CO₂ via Chemical Reaction with Alkaline Lignite Fly Ash + Extraction of Marketable Minerals & Other Commodities from Lignite Fly Ash”

CONTRACTOR: Expansion Energy

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PARTICIPANTS

<u>Sponsors</u>	<u>Cost Share</u>
GRE	\$50,000
Expansion Energy	\$50,000
NDIC	<u>\$45,000</u>
Total	\$145,000

Project Schedule – Contract Date – 6/15/16	Project Deliverables Status Report – 9/15/16 (x)
Start Date – 6/15/16 Completion Date –10/31/16	Final Report – 10/31/16 (x)

OBJECTIVE / STATEMENT OF WORK:

Expansion Energy LLC (“XE”), with participation and support from Great River Energy (“GRE”), proposes a Phase I project (“Project”) to design and estimate the capital costs for a modular pilot plant (“Pilot Plant”) utilizing XE’s patented “VCCSTM Cycle” carbon capture & utilization technology. This technology will be used to neutralize CO₂ from power plant flue gas by chemically reacting it with alkaline lignite coal ash, yielding marketable solid mineral materials, including high-value rare earth elements and metals. The VCCS technology also has the potential to reduce the need for SO₂ and particulate emissions control systems at lignite-fired power plants.

STATUS:

Interim Report

The contractor's team has expeditiously advanced the Phase I study, achieving significant milestones, which are summarized here and more fully addressed in subsequent sections of this Interim Report.

1. GRE's Spiritwood Station has been selected as the study site for this Phase I study and the possible deployment site for the proposed Phase II VCCS Pilot Plant.
2. Fly ash compositions and flow rates have been collected for Flue gas compositions, flow rates, pressures and temperatures have been collected.
3. A preliminary process flow diagram (PFD) has been developed, which has been used as the basis for a ChemCad process simulation that includes flow rates, pressures, temperatures, and which confirms that the Cycle is in material balance.
4. A 5% scale Phase II VCCS Pilot Plant design has been selected to demonstrate the CO₂ neutralization capacity of the VCCS process based on "unlimited" availability of fly ash at Spiritwood Station. The ChemCad process simulation is predicting a 72% conversion of CO₂ to CaCO₃.
5. At full commercial scale, the CO₂ neutralization capacity is expected to be limited to about 10% by weight by the relative scarcity of alkali reactants on site (i.e. fly ash) as compared to the available supply of CO₂. Various process optimizations including the addition of quicklime and import of alkalis may offer opportunities for higher conversion rates for CO₂ neutralization.

Final report

The contractor's team has completed Phase I of the subject study, achieving all of the planned milestones. The findings of Phase I are summarized here and more fully addressed in the **Final Report**.

- GRE's **Spiritwood Station** has been selected as the deployment site for the proposed Phase II VCCS Pilot Plant
- **Fly ash composition** and flow rate data have been collected for Spiritwood Station
- **Flue gas composition**, flow rates, pressures and temperature data have been collected for Spiritwood Station
- The scale of the Phase II VCCS Pilot Plant has been preliminarily established, such that the Pilot Plant's hourly fly ash neutralization capacity will be approximately **1%** of the net fly ash production at Spiritwood Station
- A **process flow diagram** (PFD) that reflects the collected data has been developed and optimized to reflect cost considerations
- The PFD was used as the basis for a ChemCad **process simulation** that includes flow rates, pressures, temperatures, and which simulation confirms that the Cycle is in energy and material balance
- Equipment specifications have been established and qualified vendors have been identified, resulting in a comprehensive list of components and vendors

- Equipment layouts (skid configurations) have been developed so that the shop-fabricated modules can be optimally placed at Spiritwood Station, connected to each other and to existing ash and flue gas streams at Spiritwood Station
- A preliminary budget for the Phase II Pilot Plant deployment has been established
- A Phase II Pilot Plan proposal will be submitted to the LRC by April 1, 2016.