

The CO₂ Capture Pilot Plant Project (C2P3)

Prospectus for Pilot Plant Testing of Advanced Concepts for CO₂ Capture by Amines

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The CO₂ Capture Pilot Plant Project (C2P3) is testing at 0.1 to 0.5 MW the innovative solvent and process concepts developed by the Texas Carbon Management Program (TxCMP) at the University of Texas. The existing pilot plant in the Separations Research Program (SRP) at the Pickle Research Campus will demonstrate energy and mass transfer performance with air/CO₂ in campaigns that last for 3 to 6 weeks. Two or more additional pilot plants will be used to provide real coal-fired flue gas at 0.1 and 0.5 MW to test solvent robustness for 3 to 6 months.

CSIRO (Australia) has funded a 0.1 MW pilot plant at Tarong that was operated by CSIRO in 2013 with piperazine solvent. The U.S. DOE is funding a 0.5 MW pilot plant at the National Carbon Capture Center (NCCC), managed by Southern Company at Wilsonville, Alabama that will be operated with TxCMP ideas in Spring 2017. Other pilot plants funded by DOE have indicated interest in testing concentrated piperazine and other ideas from the TxCMP.

The Texas Carbon Management Program has established that 30 wt % piperazine (PZ) is a superior solvent with twice the capacity and CO₂ absorption rate of 30 wt % monoethanolamine (MEA) and excellent thermal and oxidative stability. Concentrated (8 m) PZ with high T/P regeneration has proved to be an effective alternative in four pilot campaigns at SRP in Fall 2008, Fall 2010, Winter 2010, and Fall 2011. 5 m PZ was successfully tested in Fall 2013 and March 2015 with the advanced flash stripper to reduce energy and aerosol generation and with analysis to address aerosol emissions.

Testing of 5 m PZ with the advanced flash stripper at the National Carbon Capture Center (NCCC) is scheduled for March 2017. Solvent reclaiming will be used at NCCC. SRP campaigns in 2016 and 2017 are planned to test a wide range of inlet CO₂ and CO₂ removal, primarily at conditions of a hybrid amine solvent/membrane process.

The CO₂ Capture Pilot Plant Project (C2P3) project invites participation in a long-term, multiple-participant research program. We are seeking incremental funding of \$50,000/yr from existing sponsors of the Process Science and Technology Center (\$15,000/yr) or the Texas Carbon Management Program (\$30,000/yr). The participation period is defined as the calendar year, January 1 to December 31. We currently have \$150,000/yr from LG&E-KU, Southern, and EPRI.

DOE has provided \$4 million (2010–2017) as comprehensive funding for addressing aerosol formation and testing advanced stripper configurations. URS is the lead contractor on this effort. Trimeric and the University are subcontractors. This work includes 20% cost-sharing from C2P3. Long-term operation at Tarong has been supported by the Australian government and operation at NCCC in 2017 will be supported by DOE. DOE funding provided most of the support for the campaign in March 2015 at SRP.

DOE is also providing \$3 million (2013–2016) to develop a hybrid amine/membrane process. MTR is the lead contractor on this effort. C2P3 will receive \$1.5 million for modeling and two pilot plant campaigns at SRP. C2P3 and TxCMP are providing 20% cost sharing of the University portion. This funding will provide support to extend the SRP absorber from 20 to 40 ft of packing and to operate SRP pilot plant campaigns in 2016 and 2017.

As incremental funding is received into C2P3, it will be used to expand the SRP pilot plant campaigns to include operating conditions typical of a gas-fired combined cycle and of a gas-fired boiler used in the oil sands operations.

Scope of work

Task 1. SRP#1.

In August and September 2010, the existing pilot plant at SRP was modified to test absorber intercooling with 8 m PZ and with 9 m MEA using a simple stripper. This system was operated for three weeks in October 2010. In December 2010, the simple stripper was replaced with a heated 2-stage flash and operated for three weeks at pressures and temperatures up to 15 atm at 150 °C, respectively, to determine mass transfer, heat transfer, and energy performance. The pilot plant data have been reconciled and modeled with RateSep™ in Aspen Plus®.

Task 2. SRP#1b

In 2011, the existing pilot plant at SRP was modified to fix problems identified in SRP#1, including a larger cross exchanger, flow straightener wash, and a higher surface area absorber packing. A cold rich solvent bypass was added to address piperazine volatility at the flash vessel. Three weeks of testing using 8 m PZ with the modified flash skid was completed in Fall 2011.

Task 3. Tarong

In 2012, an existing pilot plant with real coal-fired flue gas at Tarong, Australia (0.1 MW) was modified by CSIRO to test absorber intercooling and pressurized stripping up to 10 atm at 150 °C. This system was operated for 3 months with 8 m PZ to quantify solvent losses, quantify nitrosamine management, measure corrosion rates, and test for other issues of solvent robustness. Solution and gas samples were analyzed periodically to quantify degradation products and estimate solvent losses.

Task 4a. SRP#2

In order to quantify aerosol growth and removal, the pilot plant at the Separations Research Program was modified in 2012 and 2013 with a sulfuric acid aerosol generator, a fiber filter mist eliminator, and instrumentation to measure aerosol size distribution. Depending on the availability of resources and time constraints, high pressure drop trays, fine mesh mist eliminator pads, and water wash with packing may also be included. Optimized designs for absorber intercooling, heat exchange, and high P separation will be included.

Task 4b. SRP#2

In Fall 2013, the modified system was operated for one week at 0.1 MW with air/CO₂ with 3.5 m PZ and 12% CO₂. A primary objective of this campaign was testing and troubleshooting of systems to generate aerosol nuclei and measure amine aerosol size distributions and concentrations. This task is in the scope of the DOE/URS contract on stripper configurations.

Task 5. SRP#3

In Spring 2015, the SRP system was tested with the advanced flash stripper and 5 m PZ. Aerosol nuclei were generated by injection of hot vaporized sulfuric acid and by injection of SO₂. Aerosol size and concentration were measured by a phase doppler interferometer (PDI) and the hot gas FTIR. This task is in the scope of the DOE/URS contract.

Task 6. SRP#4

In 2016, the SRP absorber will be lengthened to include 30 ft of packing for CO₂ absorption and 10 ft of packing for amine water wash. The pilot plant with the advanced flash stripper will be operated to test CO₂ absorption in 5 m PZ at 3, 12, 15, and 20% inlet CO₂ and CO₂ removal from 60 to 99%. The effort is primarily in the scope of the DOE/MTR contract on the hybrid amine/membrane.

Task 7. NCCC

In 2017, the 0.5 MW pilot plant at the National Carbon Capture Center will be operated for three months with 5 m PZ with the advanced flash stripper. Nitrosamine formation and decomposition will be addressed by removing NO₂ with sulfite in the SO₂ polishing scrubber. Aerosol emissions will be monitored for size distribution and minimized by operating without the trim cooler. Liquid and gas phase sampling and analysis will be maximized within the constraints of stable process operation. This task is included in the scope of the DOE/URS contract on stripper configurations.

Task 8. SRP#5

In 2017, the SRP system will be expanded to include a membrane module provided by MTR. This system will be operated to demonstrate a hybrid amine/membrane system. This effort is included in the DOE/MTR contract.

Deliverables

1. Data and interpreted results will be provided in detailed quarterly progress reports to the formal sponsors of C2P3. The interpreted results will be shared with the other sponsors of the PSTC and the TxCMP.
2. Results will be reported in a semiannual meeting associated with the meeting of the Texas Carbon Management Program.
3. A topical report will be issued on each pilot plant task within six months of its completion. It will consist of two parts: interpreted results and data. The topical report on the NCCC testing will be made available to any sponsors who participate for at least three years between 2010 and the year in which the report is issued.
4. Papers reporting the results will be prepared and submitted to peer-reviewed journals and meetings. Advance copies of the manuscripts will be provided to sponsors.
5. The interpreted results of the testing will be reported in semiannual meetings of the PSTC and the TxCMP.