Large Pilot CAER Heat Integrated Post-combustion CO_2 Capture Technology for Reducing the Cost of Electricity

DE-FE0026497

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University of Kentucky Research Foundation

Lexington, KY

http://www.caer.uky.edu/powergen/home.shtml

Presentation Outline

- Process Overview
- Knowledge Gained from 0.7MWe
- Design Basis
- Project Schedule and Deliverables
  - Tasks
  - Work Delegation
  - Status Update
- Technology Gaps

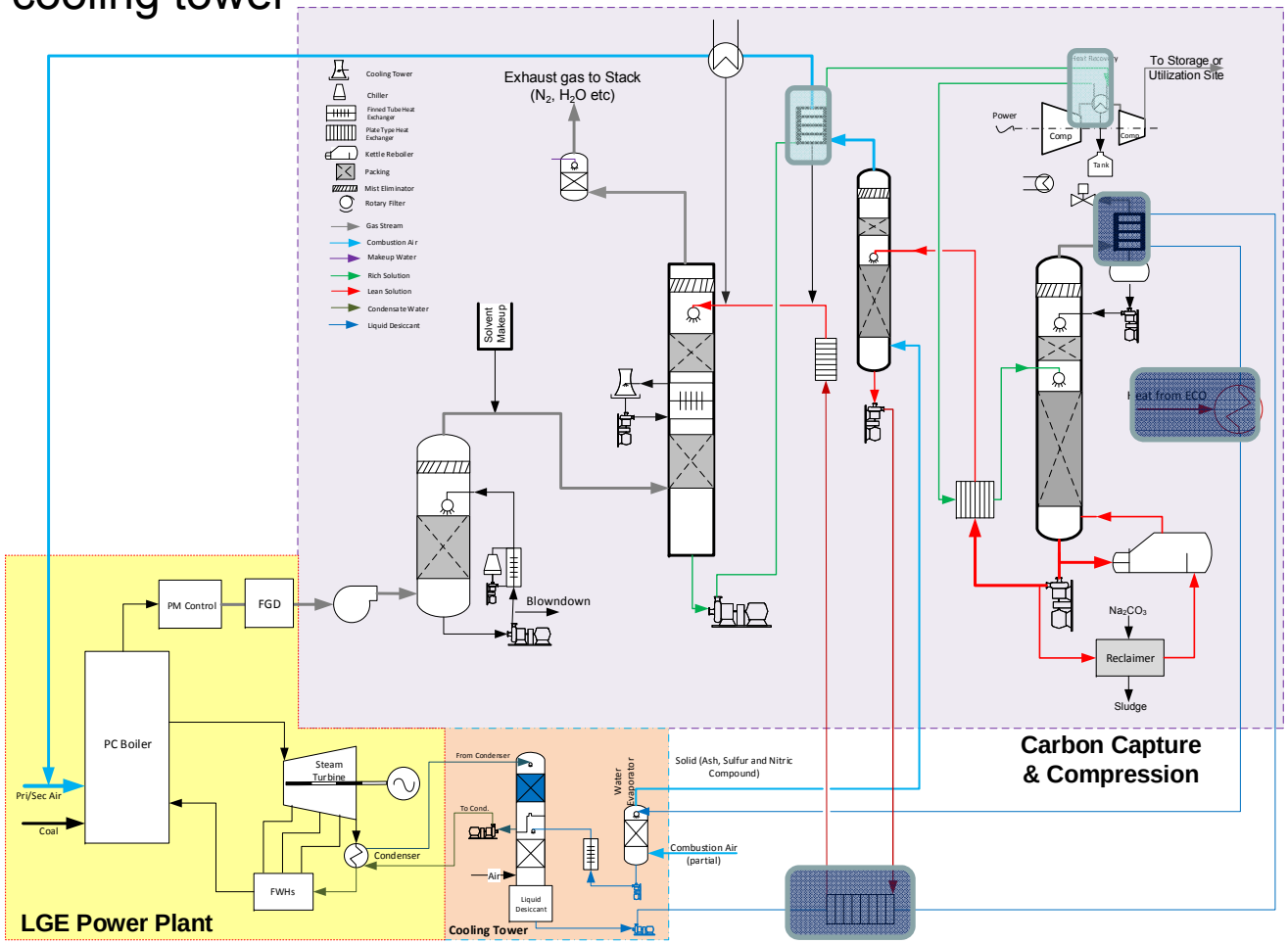
UKy-CAER Integrated Process

- Utilization of low grade heat via internal heat pump
  - Secondary stripper
  - Liquid desiccant for cooling tower

- Near-zero makeup water for amine loop

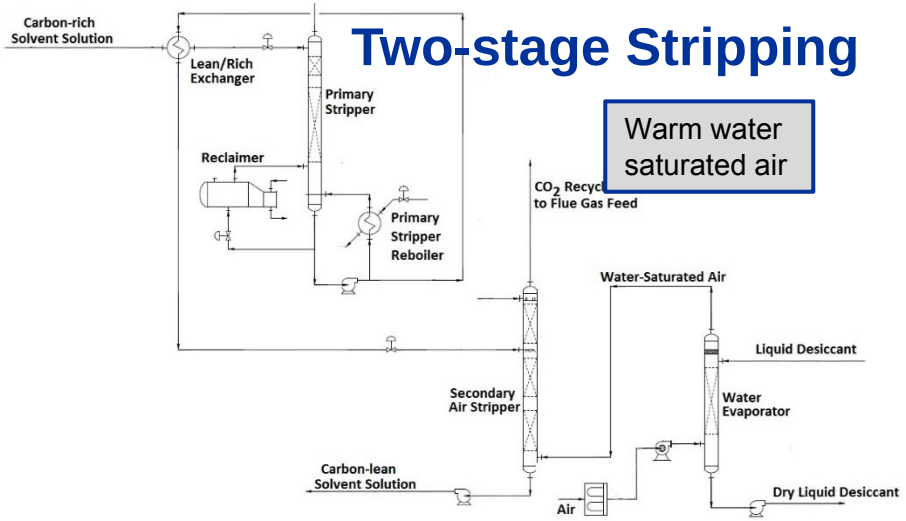
- Knowledge gained from small-pilot
  - Secondary air flowrate
  - Packing heights

- Potential utilization aspect

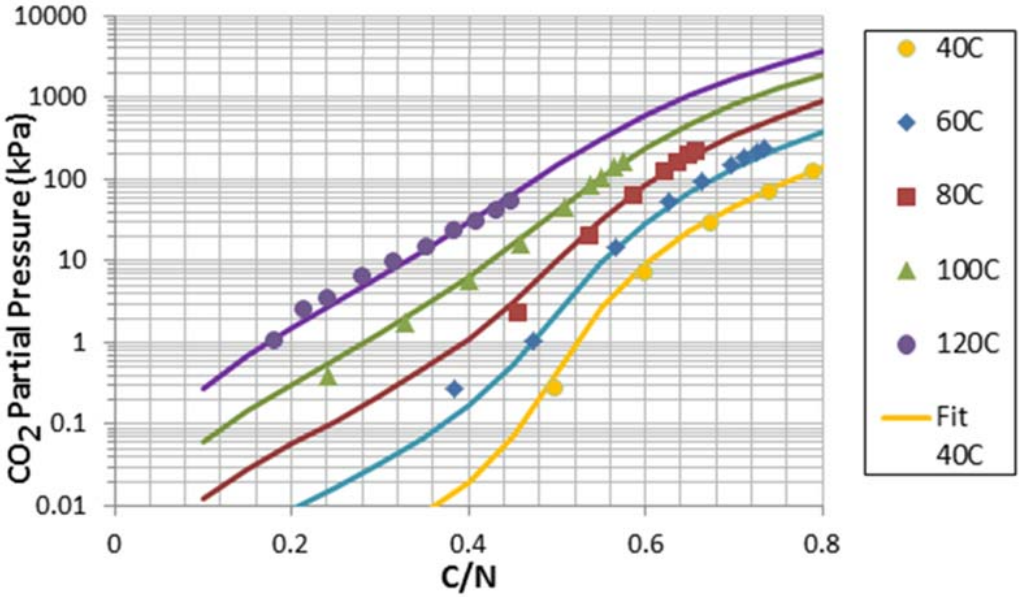


Technology Foundations (1)

Two-stage Stripping

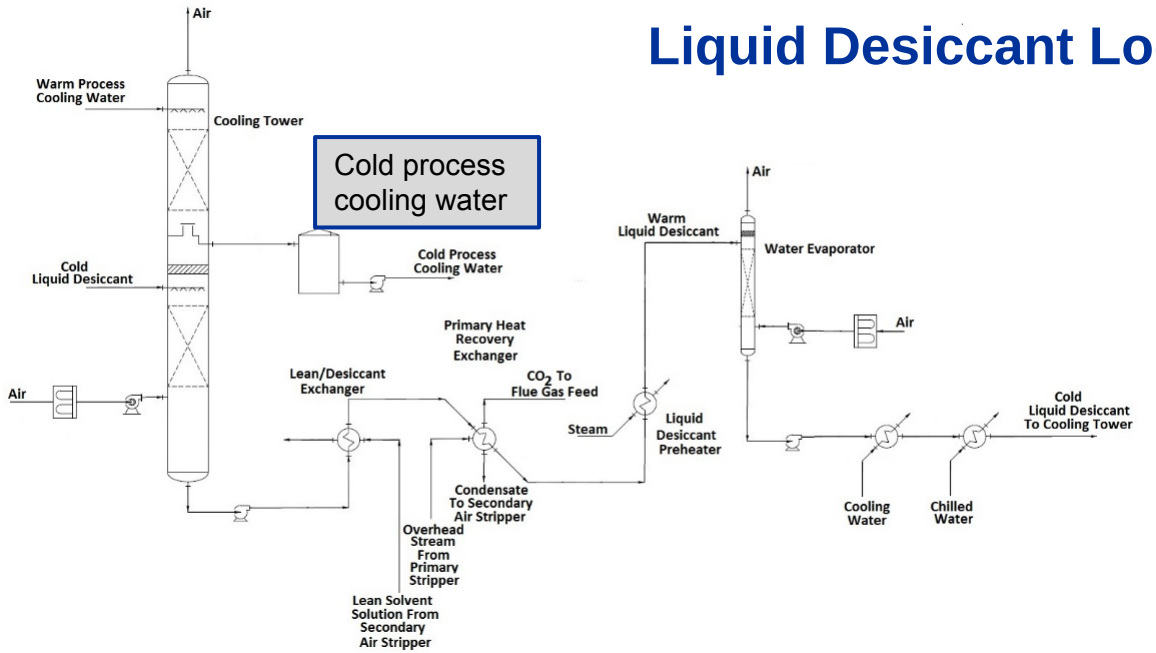


- Non-linear chemical absorption - desorption relationship between carbon loading and CO_2 partial pressure



Technology Foundations (2)

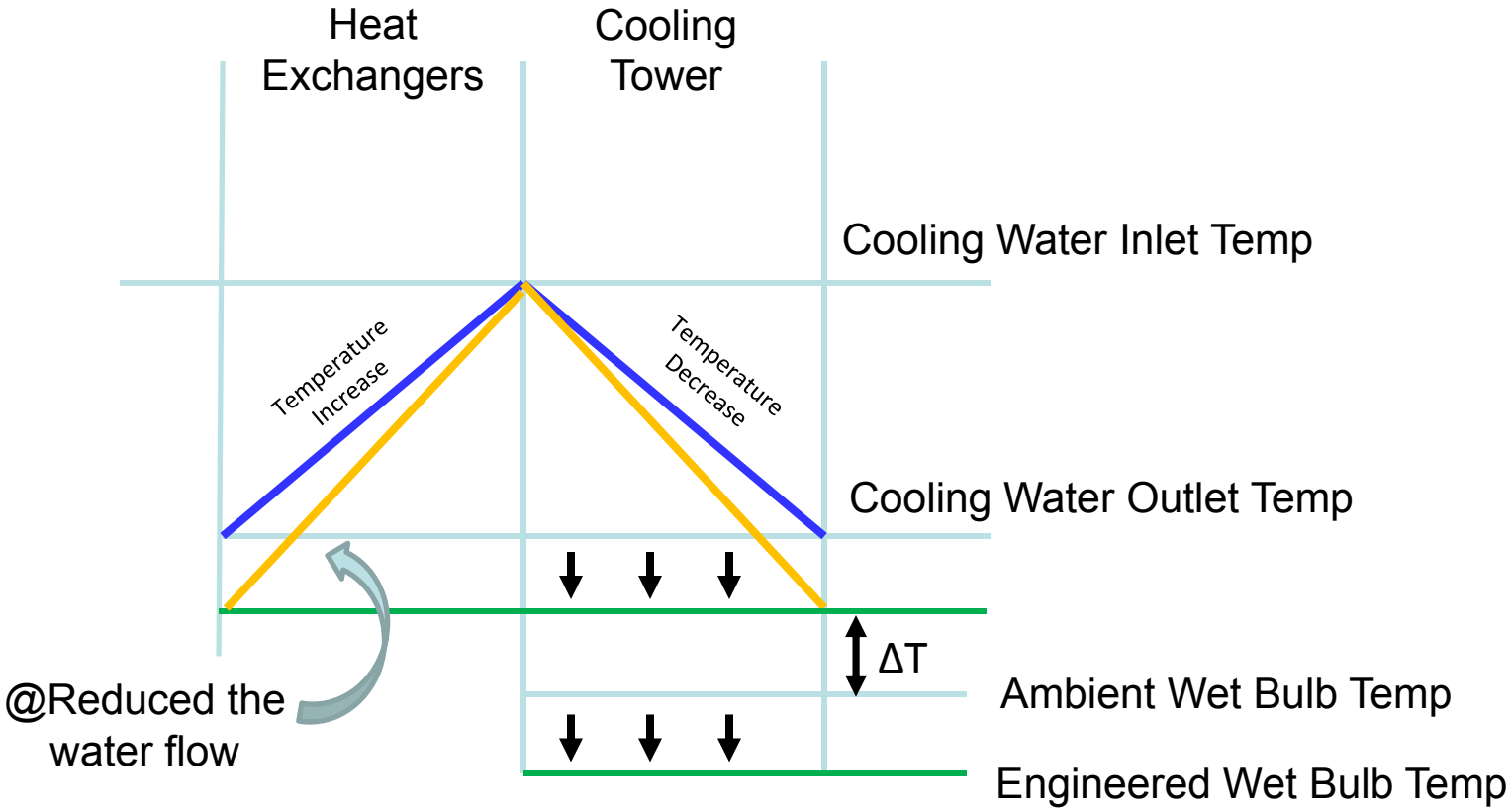
Liquid Desiccant Loop



- Non-linear relationship between relative humidity for wet air and the wet-bulb temperature

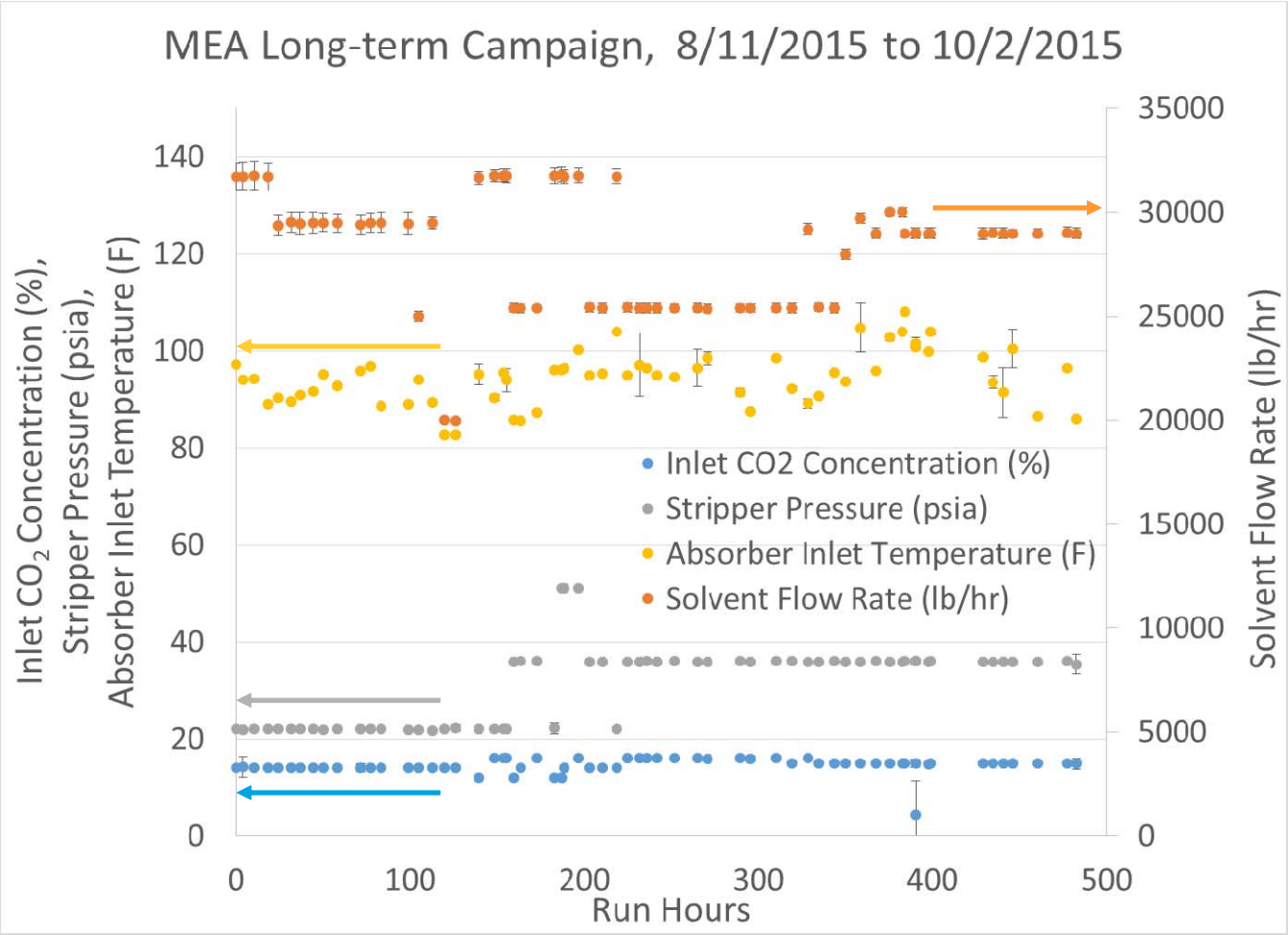
- Provide warm, water-saturated air to the secondary air stripper and provide cooling water to the system.

The Working Principle for Cooling Tower



MEA Long-term Campaign

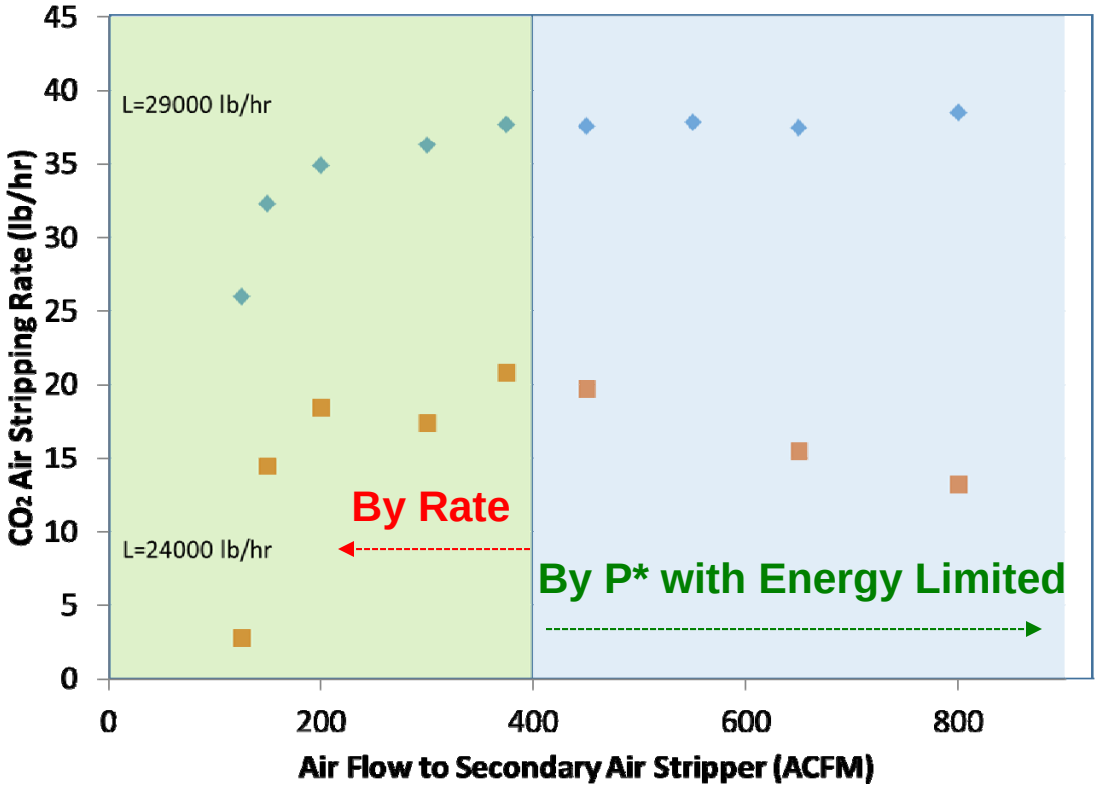
≥ 90% capture consistently obtained



MEA Long-term Campaign	
Date	**CO_2 Capture (%)**
8/11/2015	90-92
8/12/2015	91
8/13/2015	92-93
8/14/2015	92-94
8/17/2015	92
8/18/2015	90-91
8/20/2015	91
8/24/2015	95
9/2/2015	92-94
9/3/2015	92
9/4/2015	90
9/8/2015	92
9/9/2015	91
9/10/2015	93
9/23/2015	93
9/24/2015	89
9/25/2015	90
9/26/2015	90
9/28/2015	85-87
9/29/2015	86
9/30/2015	90-94

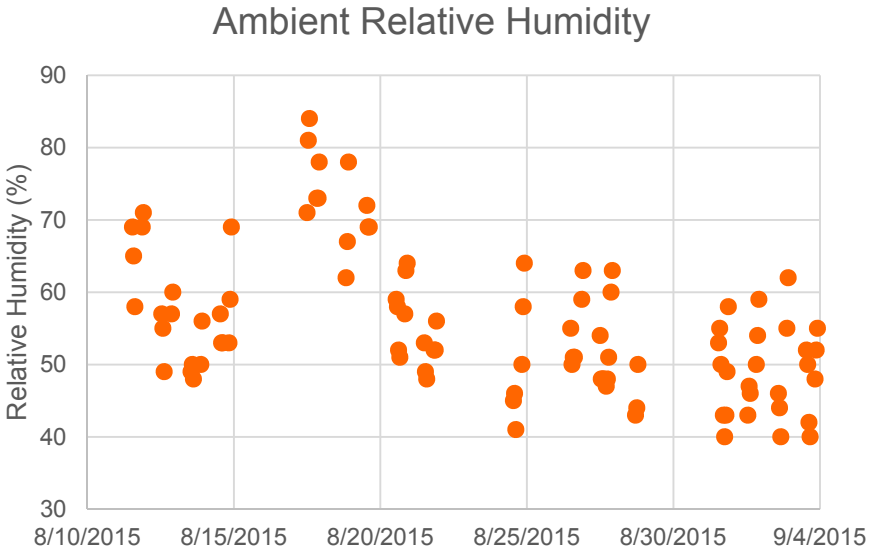
Secondary Air Flow Sensitivity

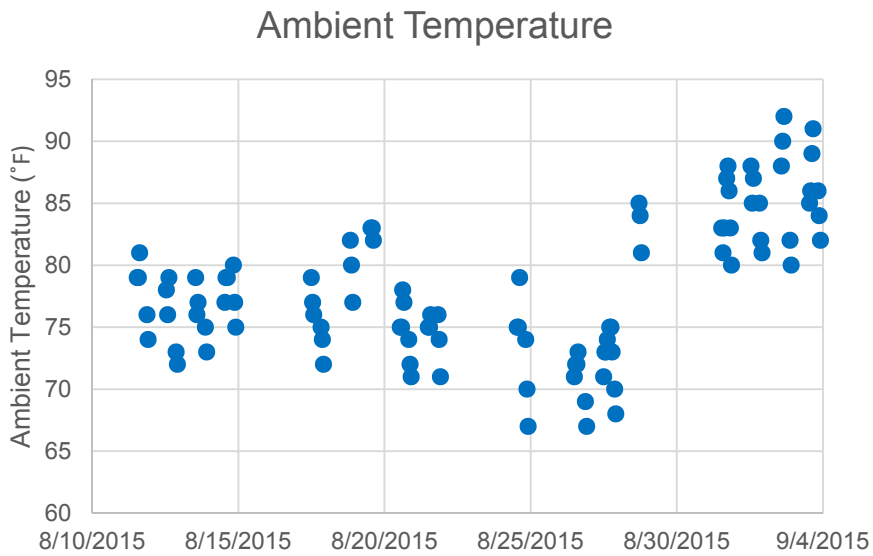
- Given:
  - Flue Gas: 1400 acfm
  - CO_2: 16.0%
  - Stripper pressure: 36 psia
  - Solvent feed to air stripper temp: 195 F
  - Alkalinity = 3.26 mol/kg

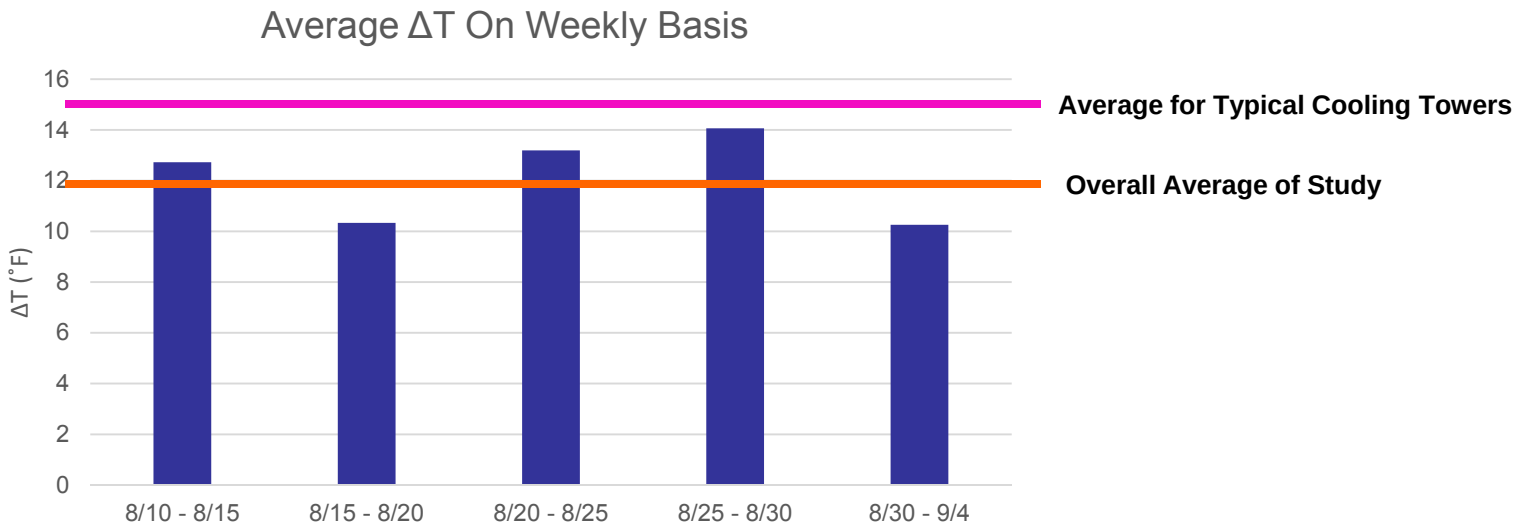


- Stripping does not increase in a linear fashion with increased air flow but is limited by the equilibrium vapor pressure of CO_2 in the air stripper.
- Beyond 400 acfm, stripping can be increased with additional heat input

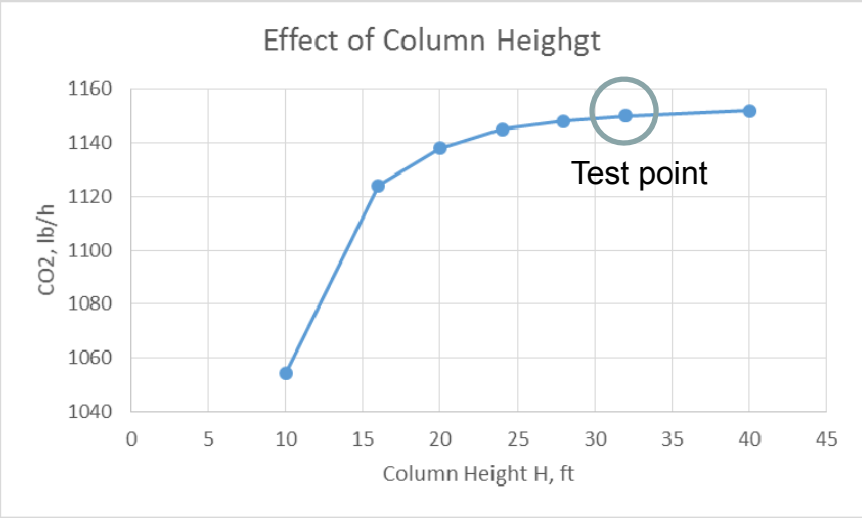
Cooling Tower Long-term Operations Data

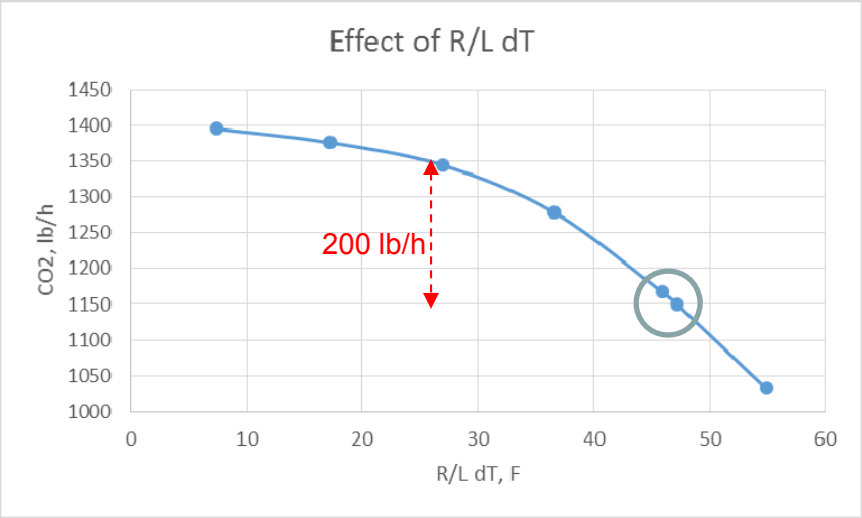




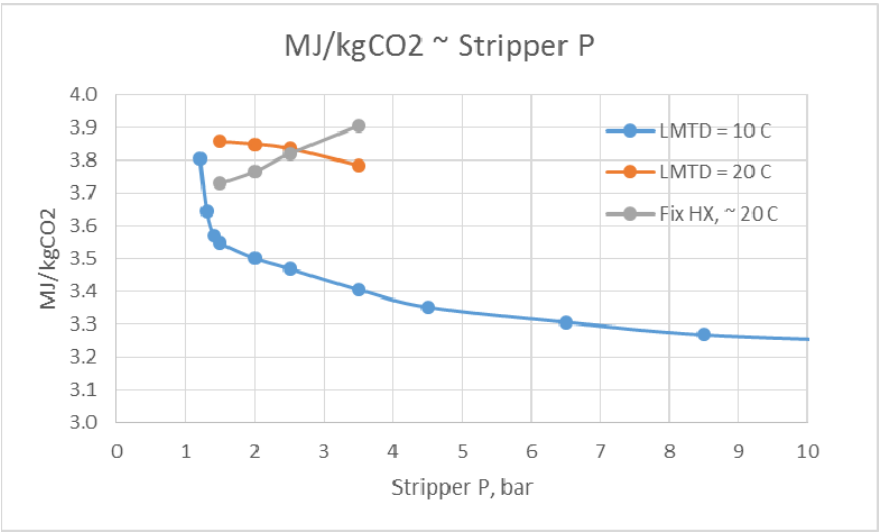


The Trade-off between Packing and EHx on Specific Energy

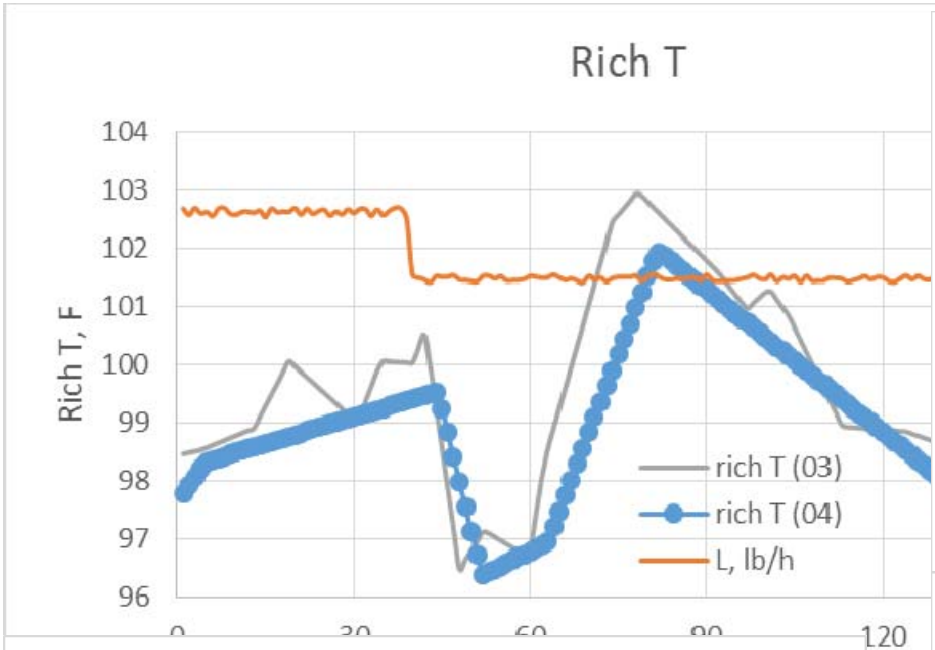


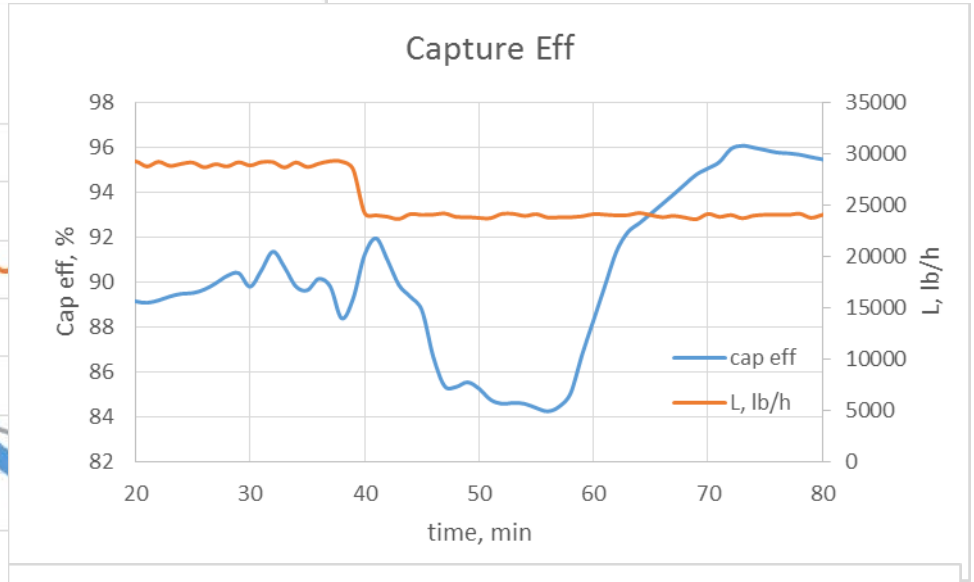


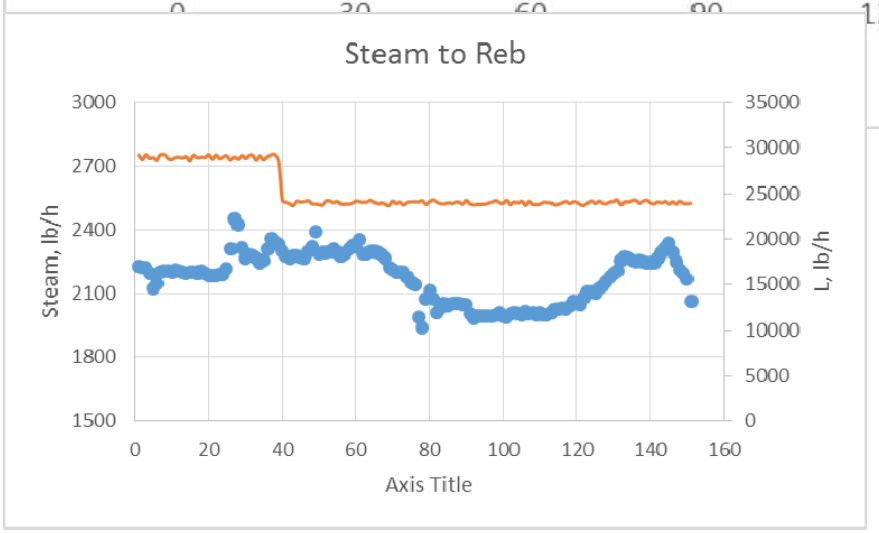
- Stripper column height
  - Gain from column height, but flattens out
  - Primary stripper is just near the turn point of flattening out
  - Again a trade-off between CAPEX and OPEX
- R/L HX
  - Gain from low R/L dT, but flattens out
  - Slipstream R/L HX seems significantly undersized (at least needs to be doubled)

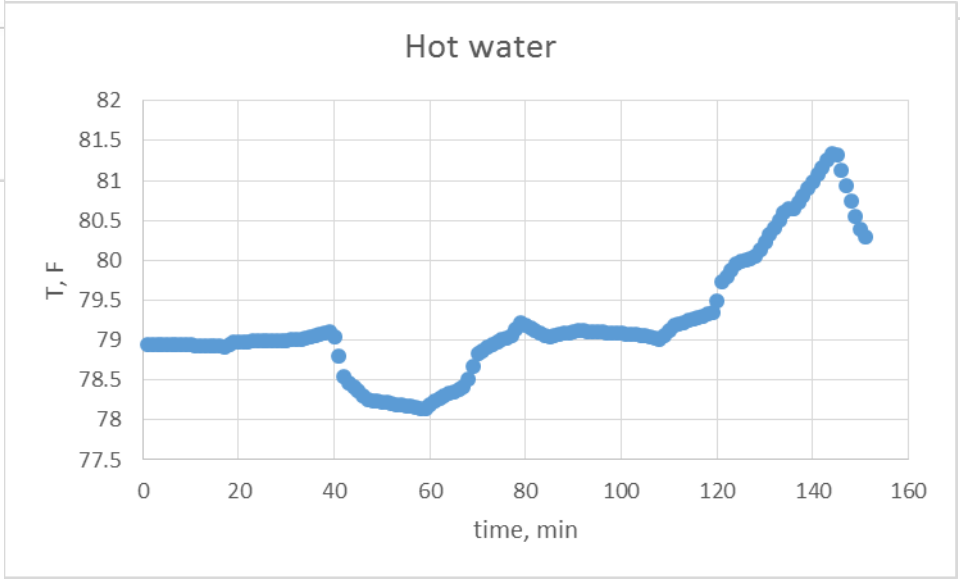


System Dynamic Response





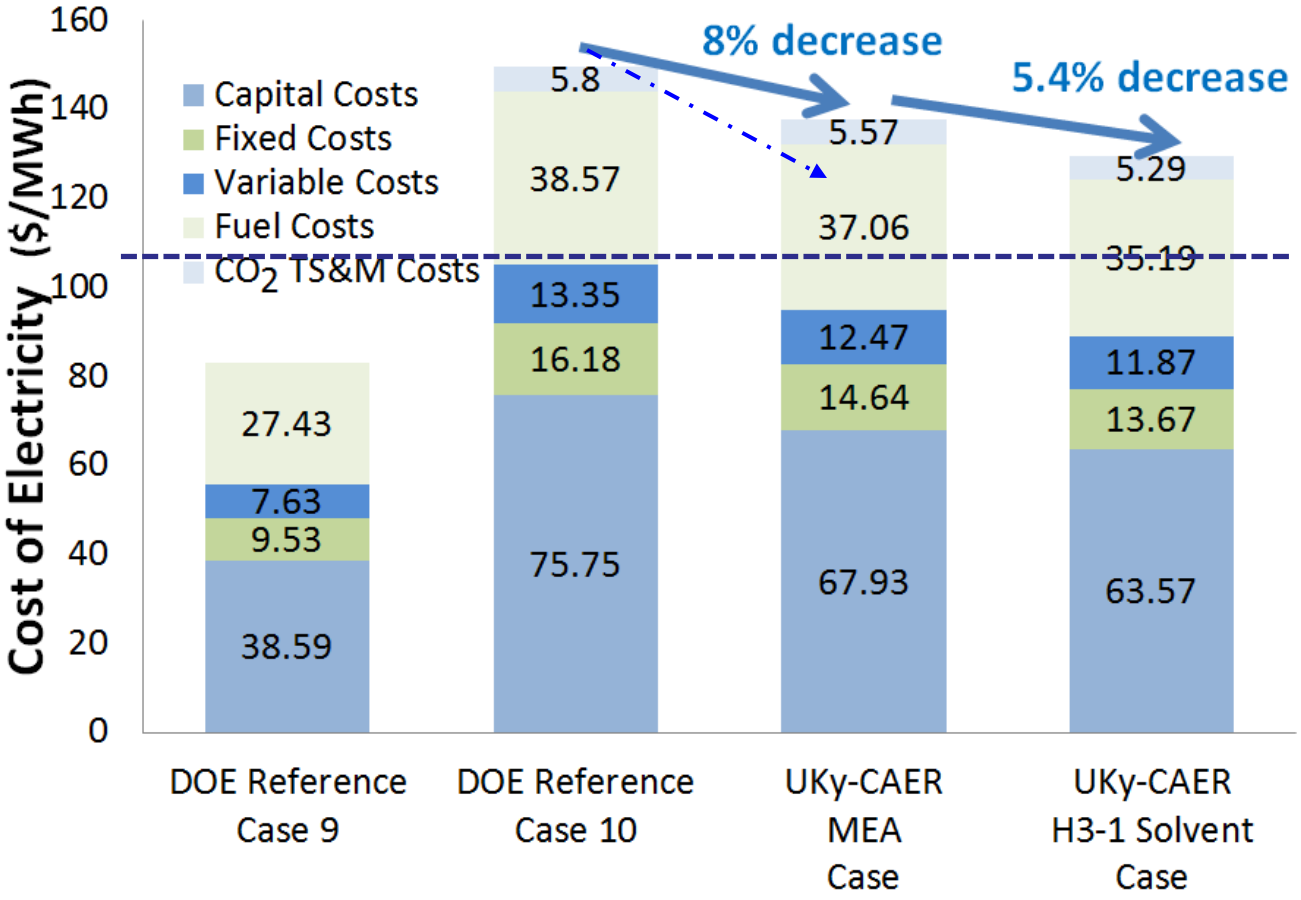




Knowledge Gained

- Absorber is rate-limited
- Stripper (primary and secondary) is equilibrium controlled
- In the view of energy penalty, the L/R heat exchanger plays a significant role for energy saving compared to absorber packing height for richer carbon loading
- Process control is challenge if 90% of capture is the only target
- CAER technology is approved at 0.7MWe scale.

Expected Cost Analysis



The capital cost will be reduced due to less HETP verified by both experimental and simulation methods

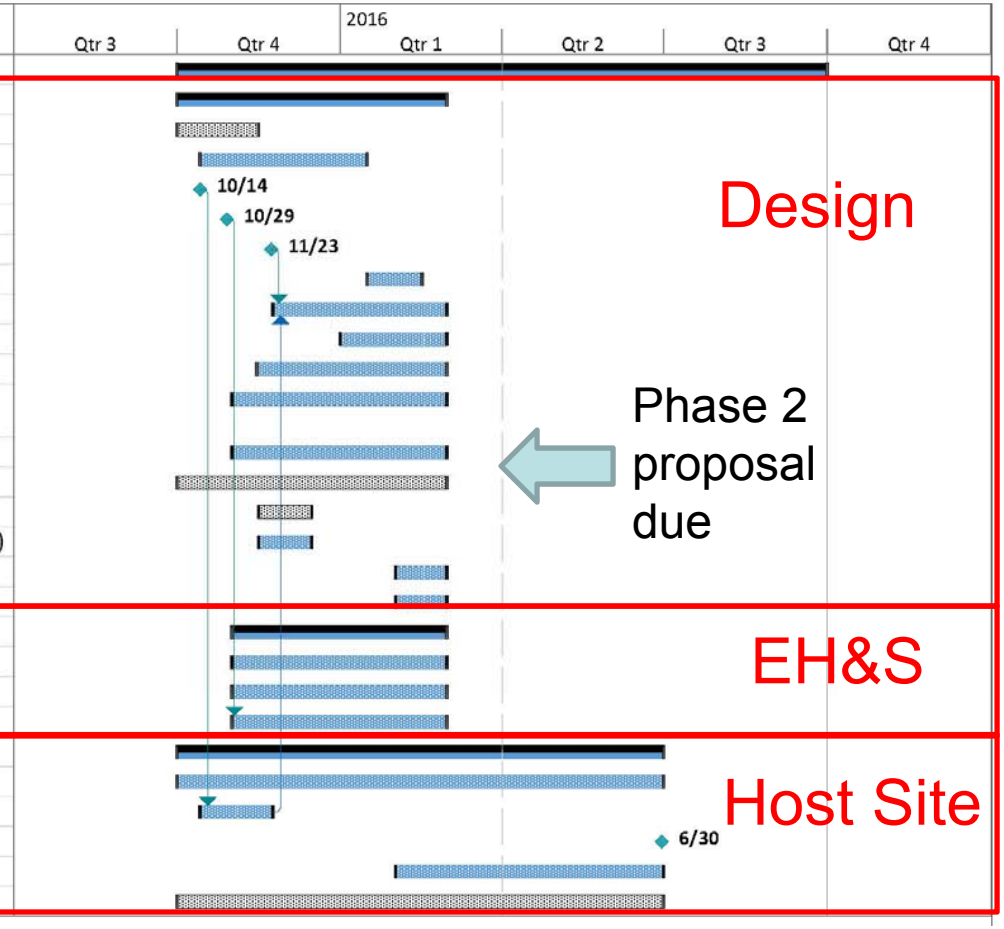
Host Site – LGE Trimble County Unit 2

- Sit on 2,200 acres
- TC 2 was on-line 2011
- 760MWe Super Criterial
  - 42- 44% HHV
  - Wall-fired, Hitachi Power
  - SCR
  - FGD
  - ESP
  - Bag House for Hg
  - Lime Injection
  - WESP

Anticipated Large Pilot 10MWe CCS Location

Project Schedule

ID	Task Name
1	1 Budget Period 1 Project Management and Planning
5	2 Basic Process Specification and Design
6	2.1 Aspen modeling of base case at 10MWe scale (UKy Lead)
8	2.2 Preliminary carbon capture system design (KMPS Lead)
9	*2.2.1 KMPS to provide approximate land requirement to UKy/WP*
10	*2.2.2 KMPS to provide general system volumes to UKy/SMG*
11	*2.2.3 KMPS to provide approximate system weights to UKy/WP*
12	2.3 Major equipment identification and selection (KMPS Lead)
14	2.4 Host site survey and general arrangement design (WP, UK and LG&E-KU)
15	2.5 Phase 2 cost estimate (KMPS and WP Lead)
16	2.6 Techno economic analysis (TEA) (EPRI and WP Lead)
18	2.7 Continuously update and revise the TEA with data collected from 0.7MW UKy-CAER small-pilot (UKy, EPRI and WP):
19	2.8 Identification of EPC candidates (WP, UKy and LG&E-KU)
20	2.9 Technology gap analysis (UKy Lead)
22	2.10 Sensitivity study - solvent selection (UKy Lead)
23	2.11 Sensitivity study - absorber column internal configuration determination (UKy and KMPS)
24	2.12 CO2 compression equipment selection (UKy and WP)
25	2.13 Steam supply selection (UKy and WP)
26	3 Complete EH&S Evaluation
27	3.1 Evaluation of Host Site Emission Permitting and Acquire Permit (if Necessary)
28	3.2 Complete Environtmental Questionnaire for Phase 2 (SMG Lead)
30	3.3 EH&S Assessment (SMG Lead)
32	4 Host Site Selection and Financial Agreements
33	4.1 Host Site Agreement Complete (UKy Lead)
34	*4.1.1 Host Site Selection (LG&E-KU)*
35	*4.1.2 Host Site Agreement*
36	4.2 Prepare Host Site Preparation/Integration Plan (UKy, KMPS and LG&E-KU)
37	4.3 Finalize Project Cost-Share Agreements (UKy Lead)



Project Budget

- Phase 1 Project Funding: $1,249,786 in total
  - $999,070 from DOE NETL
  - $250,716 cost share from the team
- Phase 1 Period of Performance:
  - October 1, 2015 – September 30, 2016

Phase 1. Resource Loaded Schedule				
Task	Task Name	Start	Finish	Task Cost
1	Project Management and Planning	10/1/2015	9/30/2016	$242,047
2	Basic Process Specification and Design	10/1/2015	3/31/2016	$696,709
3	Complete EH&S Evaluation - Phase 2	10/1/2015	3/31/2016	$152,551
4	Host Site Selection and Financial Agreements	10/1/2015	6/30/2016	$158,479

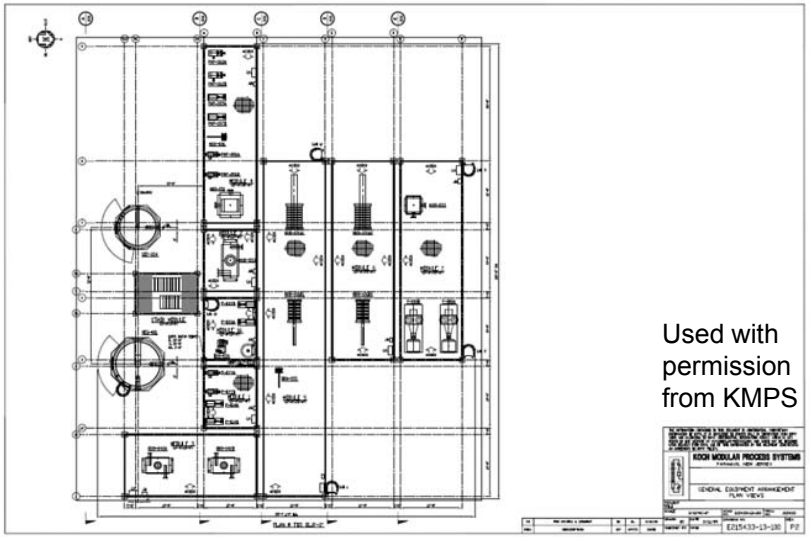
Project Deliverables

Row	Task	Deliverable by Project Task	Due Date
1	Task 1	Updated Project Management Plan	3/31/16
2		Phase 1 Topical Report and Phase 2 Budget	3/31/16
3	Task 2	Phase 1 Technology Engineering Design and Economic Analysis	3/31/16
4		Major Equipment List	3/31/16
5		Phase 1 Technology Gap Analysis	3/31/16
6		Phase 1 System Analysis Process Models	3/31/16
7	Task 3	EH&S Report	3/31/16
8		NEPA Update	3/31/16
9		Environmental Questionnaire for Phase 2	3/31/16
10	Task 4	Host Site Agreement	6/30/16
11		Financial Agreements	6/30/16

CCS Specification & Design

Highlighted Subtasks and Accomplishments

- Preliminary System Design (KMPS)
- Host Site Survey and General Arrangement Design (WP, LG&E-KU, UKRF)
  - KMPS provided first GA estimate of 0.75 acres. Final estimate to be provided by February
  - KMPS to provide first estimate of system weights and sized equipment by end of November and final estimate by February.
- Phase 2 Cost Estimate (KMPS, WP)
- Update and Revise TEA with data from 0.7MWe small pilot (EPRI, UKRF)
- Identification of EPC
- CO_2 Compression Equipment Selection (WP) if allowed
  - Specification on CO_2 for EOR received.



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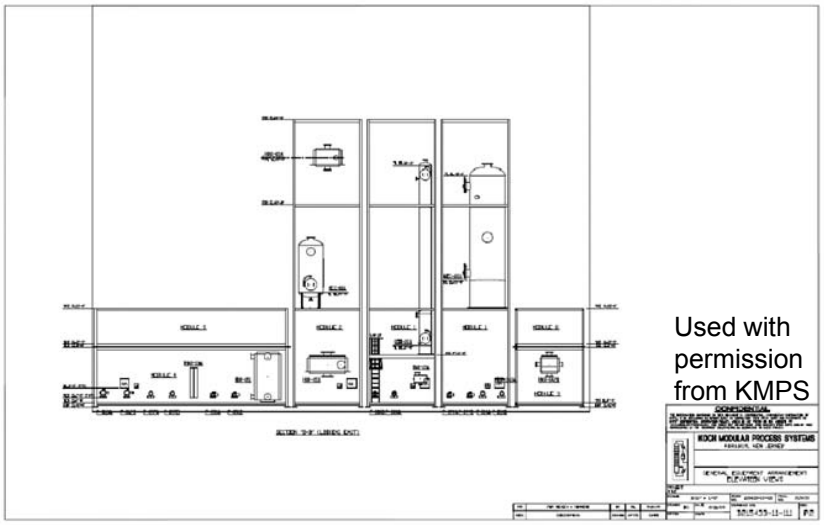

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EH&S Evaluation (SMG)

- All potential air and water emissions as well as solid wastes produced
- Waste stream characterization and emissions from Slipstream (0.7MWe)
- Include by-products and degradation products
- Compliance and regulatory implications of proposed technology
- Engineering analysis to eliminate or minimize potentially hazardous material
- Safe handling (PPE) and spill prevention/containment
- Safe storage (including incompatibilities) and accidental release measures
- Update on Phase 2 EH&S Assessment
  - KMPS to provide sized equipment estimate by end of November.
  - Final sizes by February

Project Management

Accomplishments

- Updated PMP, October 28th
- All Phase 1 contracts executed, October 1st
- Kick-off Meeting with all team members, October 14th
- Detailed Schedule and interim Milestones coordinated (Engineering design and reports)
- KMPS, WP, and SMG work underway
- On-going discussion with UK administration on how to execute the project if Phase II is granted
- Detailed plan for Phase 2 Proposal Submission by 3/31/16
- Briefs and Reports (due 3/31/16)
  - TEA
  - Technology Gap Assessment
  - EH&S Report and Environmental Questionnaire
  - Topical Report on Pilot Plant and Proposal for Phase 2

Acknowledgements

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Electric Power Research Institute