

CO₂ Capture at LG&E Cane Run NGCC Power Plant

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Acknowledgement and Disclaimer

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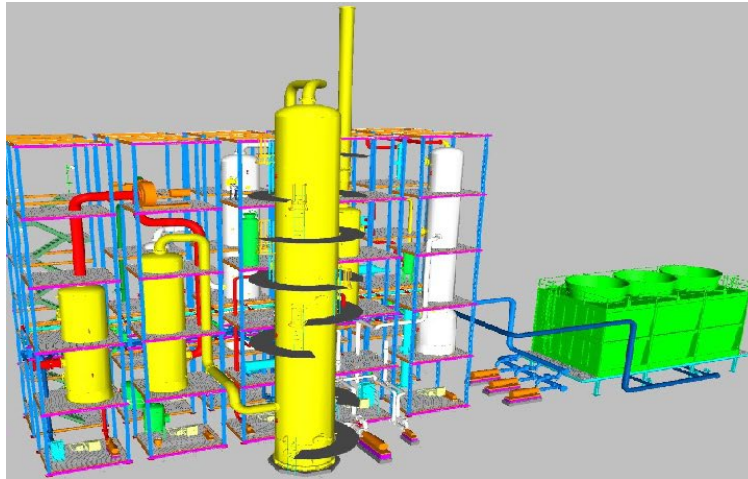


U.S. DEPARTMENT OF
ENERGY



Project Overview

- FEED study for retrofitting the LG&E (a PPL Corporation Facility) Cane Run Unit 7, a 640 MW NGCC located in Louisville KY, with the University of Kentucky's solvent-based carbon capture system
- Funding = \$7,3303,164. DOE \$5,842,517 + Cost-share \$1,460,647
- Project performance dates 12/22/2022 – 8/31/2025



Source UK



Source PPL

Project Team

- **EPRI:** Non-profit, electric sector R&D; prime
- **Louisville Gas and Electric & Kentucky Utilities, a PPL Company (PPL):** owners of Cane Run Unit 7 NGCC plant located just SW of Louisville, KY along the Ohio River
- **University of Kentucky (UK)** Carbon capture technology developers
 - **Vogt Power International:** HRSG OEM, subcontractor to UK
 - **ALL4:** Performing EH&S, subcontractor to UK
- **Bechtel:** Performing Front-End Engineering and Design (FEED)
- **University of Michigan:** Global CO₂ Initiative for LCA



PPL companies

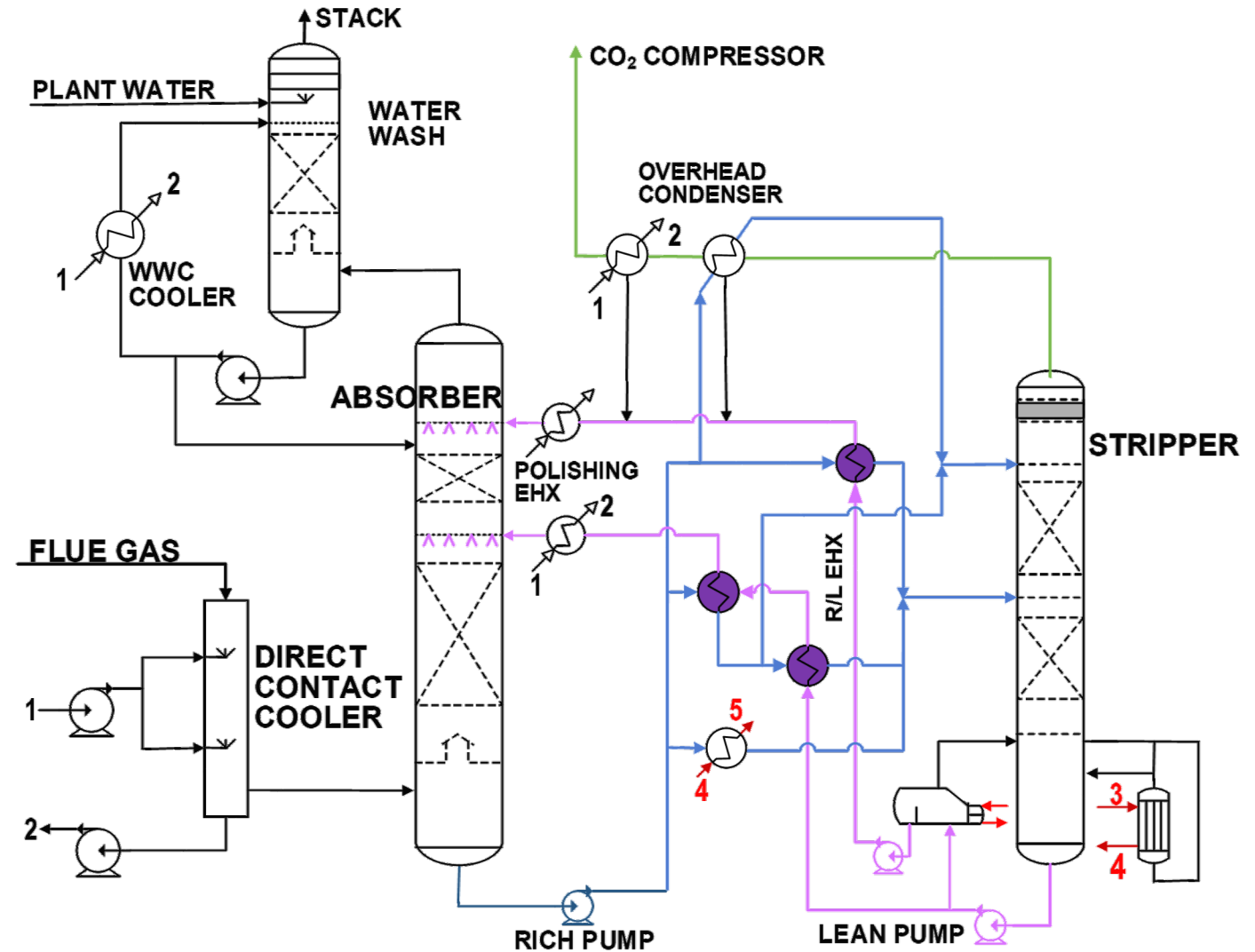


A Babcock Power Inc. Company



UK CCS Process

- Aqueous amine solvent
- Split lean solvent feed to absorber
 - 95% capture rate
- Split rich solvent feed to stripper
 - Reboiler duty 1040 BTU/lb (2.42 MJ/kg)
- In-duct water spray flue gas cooling
 - Reduced capital cost



Source UK

UK CCS Experience

- Active research since 2006
- Technology validated and scaled up from lab to pilot scales
- >10,000 operational hours on coal and simulated-NGCC flue gas
- Solvent with \$6.5kg/chemical cost, 0.6 kg/tonne CO₂ make-up rate, and Aspen Plus[®] model experimentally verified at pilot scale



Cane Run 7 – Host Site

- **Location:** Louisville, KY
- **Capacity:** 640 MW
- **Fuel:** Natural Gas
- **Opened:** 2015
 - Cane Run 7 is Kentucky's first natural gas combined-cycle (NGCC) generating unit
- **Retirements:**
 - Coal units 1 through 6 were demolished in 2019
- **Capacity Factor:**
 - ~85% from 2016-2021

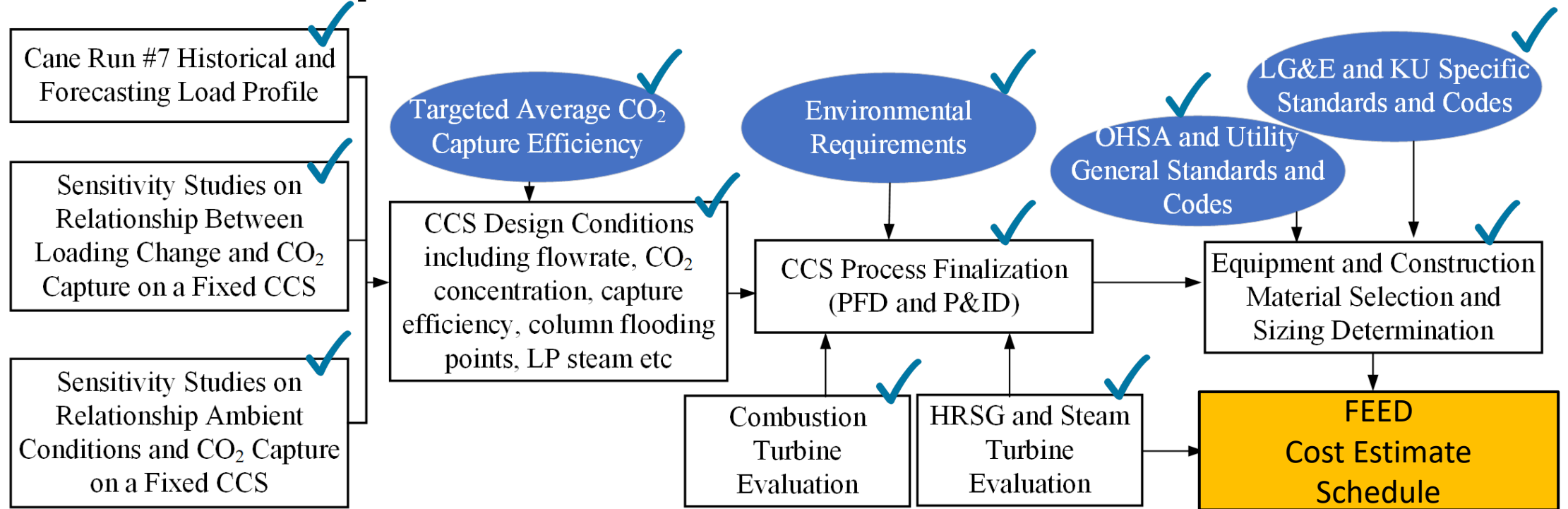


Source LGE-KU/PPL



Source LGE-KU/PPL

Pre-FEED Completed

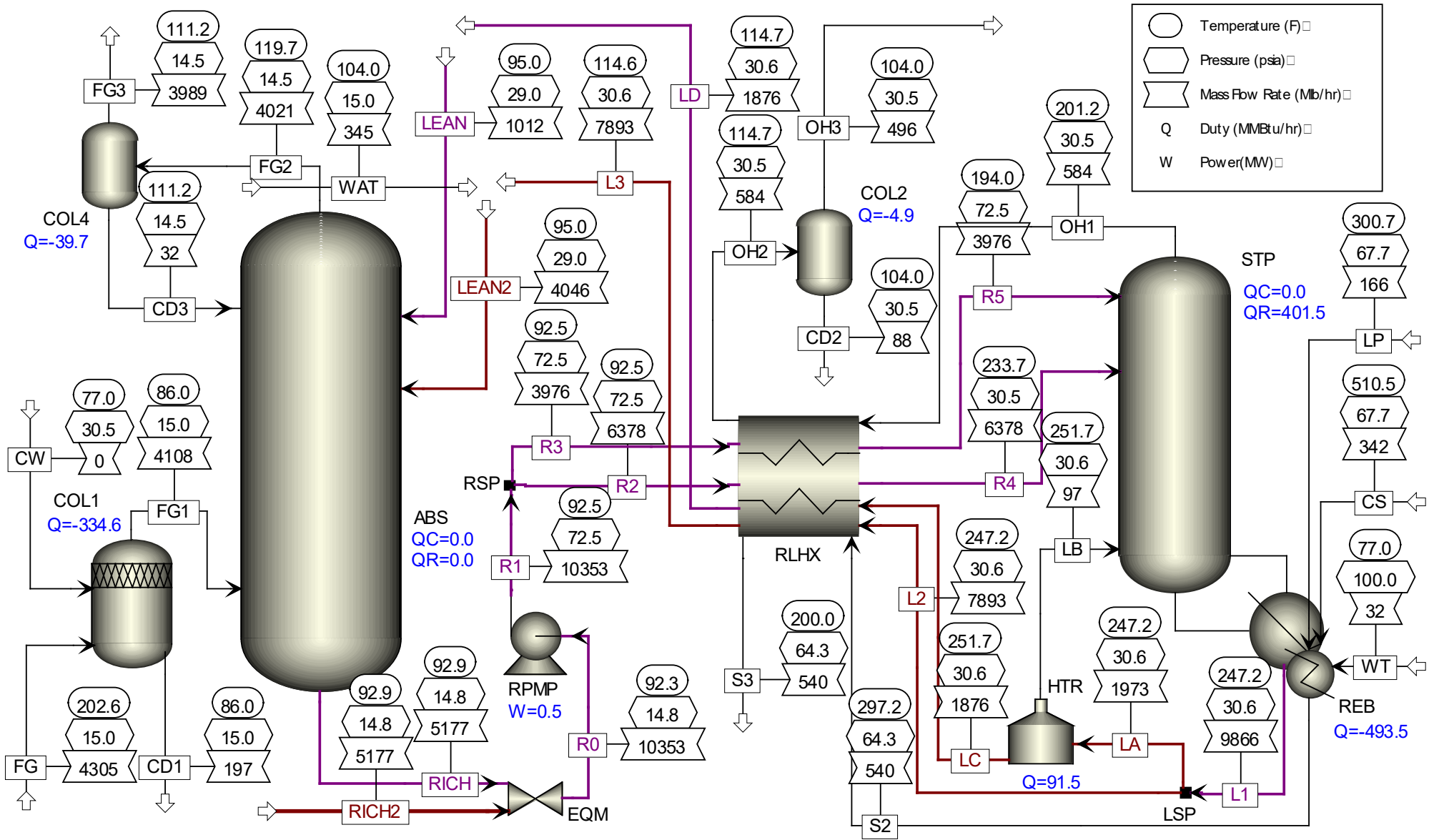


- >95% equipment/process service factor
- Baseload condition based on historic & forecasted generation data
- Solvent-independent design
- Design for reliability and operability
- Full-plant integration and CT operation impact analysis

- Vogt Power on team to analyze:
 - Impact on HRSG operations
 - In-duct cooling, without DCC
 - Elimination of flue gas boost fan, with HRSG accommodating additional pressure
 - Best steam extraction location and impact on steam cycle

✓ - Completed

Design Heat and Mass Balance



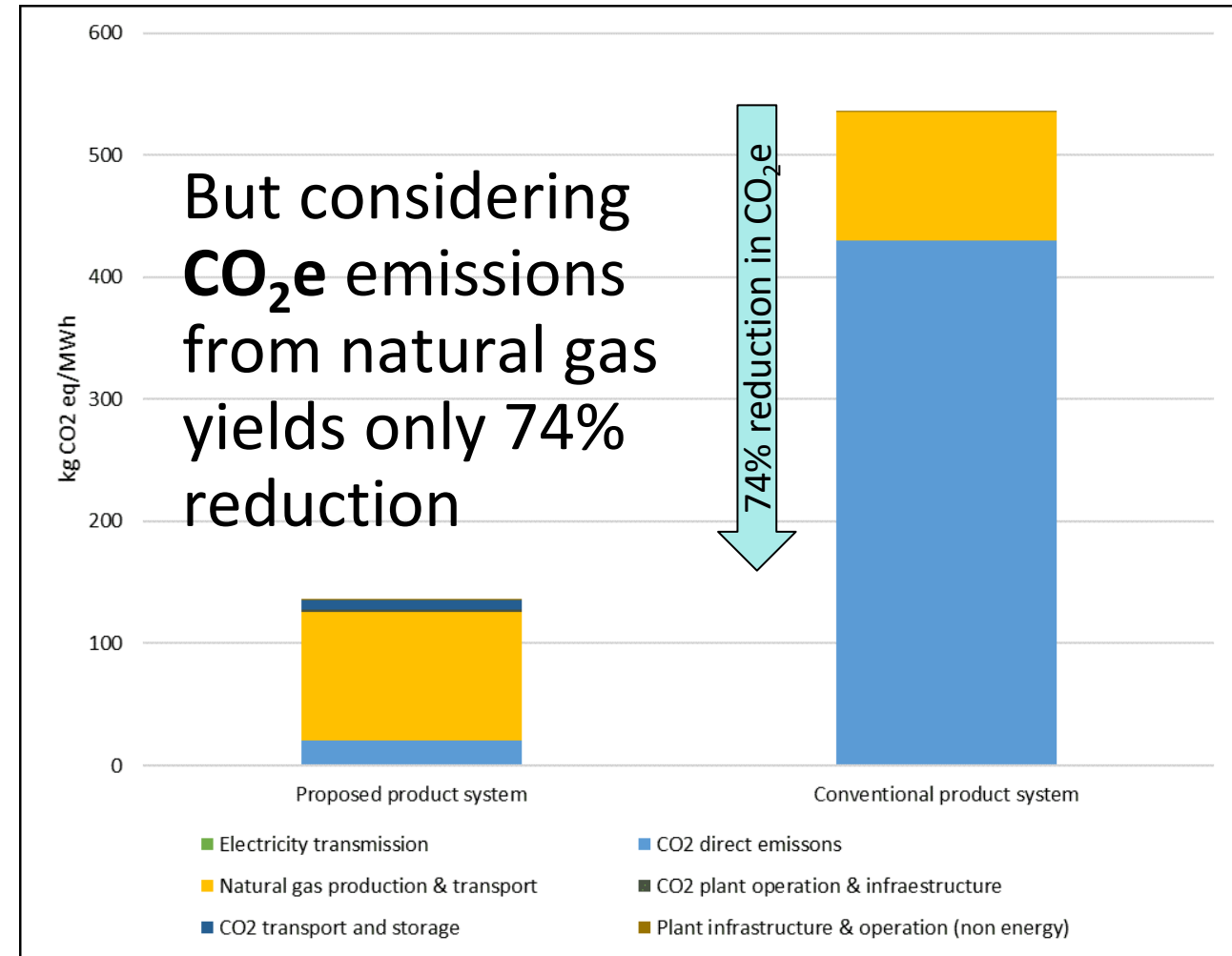
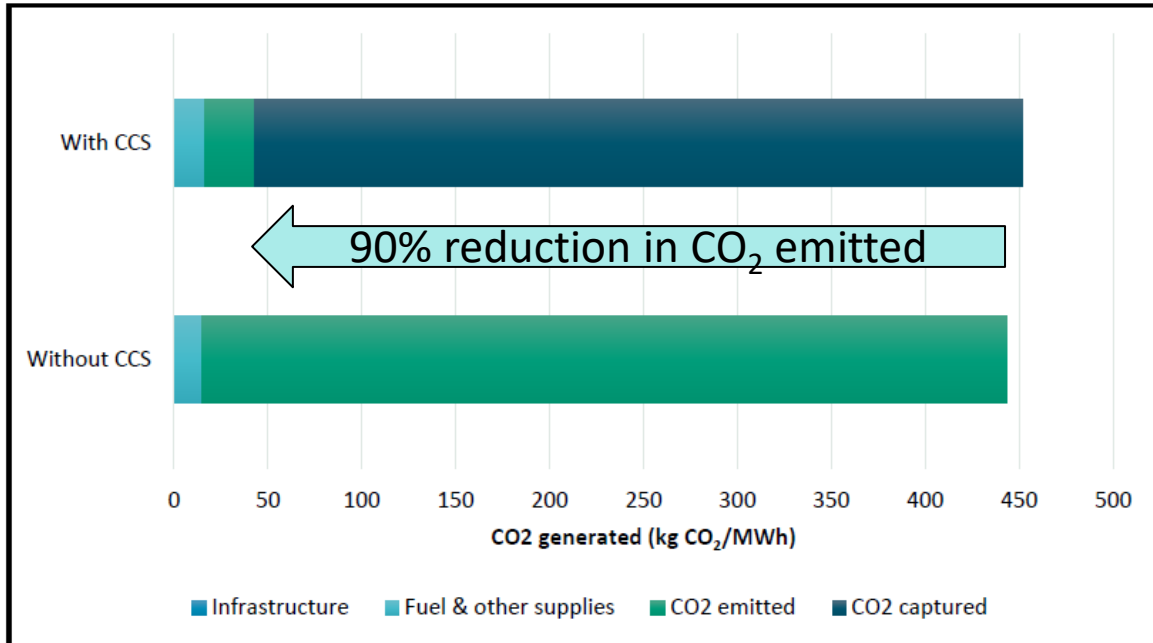
Energy Consumption

Without CCS Gross Power Output	Cane Run Study		Rev 4 Case 31B
		kW	699,026
Estimated other Balance of Plant	kW	16,040	14,000
Cane Run without CCS Net Power	kW	682,986	727,000
With CCS Gross Power Output			
	kW	659,545	690,000
CO ₂ compression	kW	18,200	17,090
Flue gas boost fan for CCS island	kW	0	10,600
Estimated CO ₂ Capture Auxiliary (pumps etc) excluding boost fan	kW	7,400	
Estimated other Balance of Plant	kW	16,040	16,372
Estimated Net Power Output	kW	617,905	646,000
Total derate	kW	65,081	81,000
	%	9.3%	10.9%
CO ₂ Capture Rate		95%	90%
CO ₂ Captured @ 95% efficiency	t/hr	227	224
Energy Penalty	KWh/t CO ₂	286.8	361.6

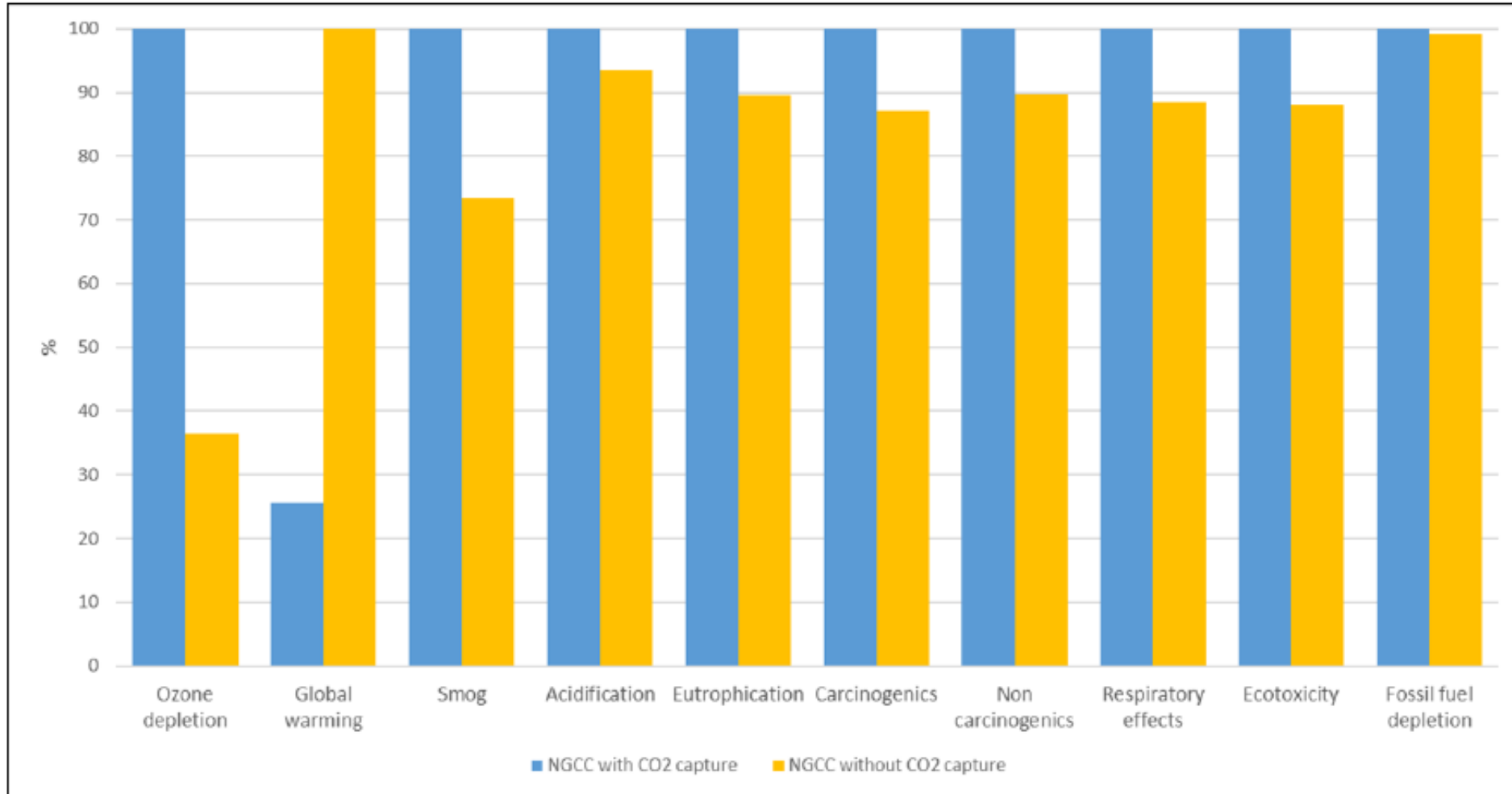
Process and integration improvements result in expected >20% reduction in energy penalty per kg CO₂ captured compared to NETL Bituminous Baseline rev. 4 Case 31b

Initial LCA Results

95% of CO₂ captured reduces CO₂ emissions by ~90%



Initial LCA Results



- GWP reduction from CCS, but all other impact categories increased as additional built environment / fuel use required.

Next Steps: Feed Study

- FEED submission
- Reviews and revisions
- Class 3 cost estimate
- Transportation and logistics
- Quantity takeoffs
- Schedule
- Construction plan/Story boards
- Engineering, procurement and construction implementation plan
- Vendor quotes
- Material requisitions/RFQ'S
- Model Development (CAD)
- Layout
- Equipment lists
- Equipment designs/Selection
- Piping and Instrumentation Diagrams (P&ID's)
- HazOp
- Revised P&ID's
- Uncertainties Log
- Risk register
- Management control and reports

Community Benefits and Societal Impacts

- Planned evaluation of community impacts:
 - Environmental co-benefits of CO₂ capture
 - Workforce development and jobs creation
 - Economic impact
 - Development of community engagement strategy
- Societal Impacts
 - Accelerating decarbonization through de-risking CCS
 - All information to be made public except confidential vendor information
 - Potential for lowering energy and capital costs of CO₂ capture

Lessons Learned

- Design philosophy of reliability and operability has increasing importance for real-world deployment
- Increasing backpressure on gas turbine possible mechanism to eliminate FD fan
 - Requires collaboration between GT supplier, HRSG, and carbon capture
- Optimization of steam extraction point from NGCC requires full HRSG and steam turbine models
 - Modification possible, but important to bring in OEMs to understand repercussions from performance and service agreements

The FEED study will guide CCS scale up

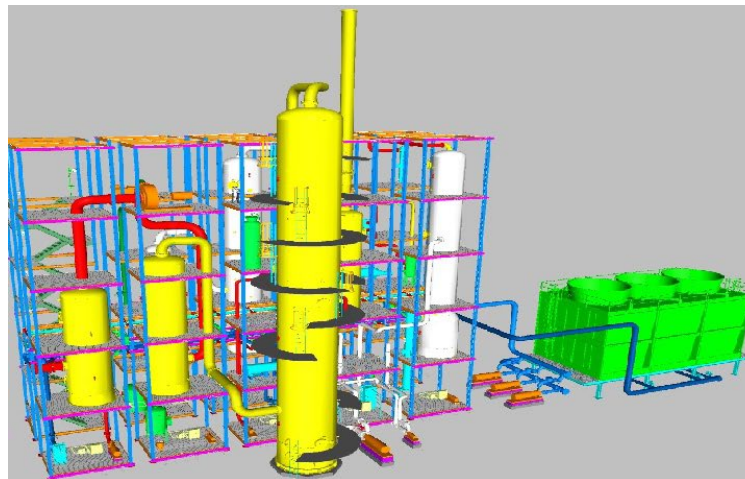
- Evaluate the impact of the carbon capture process on:
 - Power delivery and cost for full scale deployment
 - The operation and possible modifications to the HRSG and steam turbine.
- Land and Permit Requirements
 - This includes the CCS system layout and long-term planning for possible future NGCC units at the site.
- Evaluation of Local Storage and Pipeline Options
- The FEED learnings combined with planned 20 MW demonstration capture unit will inform CCS at Cane Run Unit 7



Source PPL

Summary

- FEED study for retrofitting the LG&E (a PPL Corporation Facility) Cane Run Unit 7, a 640 MW NGCC located in Louisville KY, with the University of Kentucky's solvent-based carbon capture system for 95% CO₂ capture
- Pre-FEED nearly complete with promising performance estimates
- All results to be made public other than confidential vendor information



Source UK



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