UH Energy
UNIVERSITY OF HOUSTON

TIEEP

TEXAS INDUSTRIAL ENERGY
EFFICIENCY PROGRAM

Highlights from the Texas Industrial Energy Efficiency Program

Newsletter Volume 7, Number 2, October 2025

Greetings from the Texas Industrial Energy Efficiency Program!

Upcoming Events

Energy Day

Saturday, October 18, 2025, 11:00 am - 3:00 pm
Sam Houston Park | Downtown Houston
TIEEP will host a table in the UH Energy tent at this citywide STEM outreach event. Stop by and explore our interactive exhibit - we'd love to see you there!

Energy Talk Series

The UH Energy Coalition continues the educational Energy Talk Series on the main campus of the University of Houston. See the Energy and Innovation Event Calendar for dates and times.

SPEER Webinars

The South-central Partnership for Energy Efficiency as a Resource (SPEER) hosts webinars focusing on commercial and small businesses. Check out their website, www.eepartnership.org/events/ for more details.

Coogs for Energy Hackathon

November 21 - 22, 2025
Student Center South | University of Houston
Join us for the 2025 Fall edition of the Coogs for Energy Hackathon, an exciting challenge where students from various disciplines collaborate to design innovative solutions to real-world energy problems.

Industrial Energy Efficiency Podcast

Stay tuned for our upcoming new podcast launching this month!

Last Month's Events

2025 Southwest Process Technology Conference
September 22 - 23, 2025 | University of Houston

U.S. Department of Energy's - Energy Intensive Industries Initiative

Paul Scheinhing
(Principal, 50001 Strategies LLC)

Jimmy Kumana
(Principal, Kumana and Associates)

The U.S. Department of Energy's Energy-Intensive Industries Initiative, led by Oak Ridge National Laboratory, is helping high-energy sectors such as chemicals, steel, and food manufacturing improve efficiency, cut costs, and maximize production capabilities. Through technical assistance and tools like Pinch Analysis, the program has already identified 4.12 trillion BTU and $32 million in annual savings across participating facilities. By addressing workforce skill gaps and promoting low-cost, high-impact efficiency upgrades, the initiative intends to improve U.S. industrial competitiveness and sustainability.

Various Approaches for Identifying Energy Efficiency Opportunities in Pumping Systems

Bryan White
(Senior Field Engineer, Flowserve
Energy Advantage Program)

Flowserve's Energy Advantage Program, showcased at the 2025 STS-AIChE Conference, highlights data-driven methods for improving pumping system efficiency and cutting operational costs. By optimizing pump hydraulics, valve configurations, and drive systems, plants can achieve substantial energy and carbon reductions, especially in systems over 150 horsepower or operating below optimal valve openings. Through detailed assessments and modeling, Flowserve identifies re-rate and retrofit opportunities that deliver strong ROI while advancing several industrial sustainability goals.

Pinch Analysis of a Complex Reboiler System

Mark Potter, P.E.
(Staff Process Engineer, TPC Group)

TPC Group engineers applied Pinch Analysis to optimize a complex reboiler system, identifying over 20 MMBtu of potential heat recovery through improved heat integration. Installing a new 14 MMBtu exchanger reduced both steam and cooling water demand, demonstrating strong energy and cost savings. Despite some operational challenges, the project confirmed that systematic Pinch Analysis can uncover valuable efficiency opportunities and guide practical, capital-justified improvements in industrial heat systems.

Low-Cost Intelligent Diagnostics for Industrial Equipment

Dr. Bryan Rasmussen
(Professor, Texas A&M University)

Dr. Bryan Rasmussen presented low-cost intelligent diagnostics as a practical approach to improving industrial energy efficiency. He emphasizes this to be a new industrial revolution of Cyber-Physical Systems. By leveraging the Industrial Internet of Things and existing sensor data, facilities can detect inefficiencies in systems like motors, compressors, and HVAC equipment without expensive upgrades. These data-driven methods enable predictive maintenance and optimized energy use, making efficiency gains more accessible and cost-effective for industry.

Expanding Enterprise-Wide Monitoring to Steam Systems and Crude Preheat Trains for Enhanced Energy Optimization

Bill Hicks
(Principal Sustainability Process
Engineer, ExxonMobil)

This presentation discussed ExxonMobil's Energy Fleet program that expands enterprise-wide monitoring to steam systems and crude preheat trains to drive continuous energy optimization. By using real-time dashboards and performance benchmarking, the system identifies inefficiencies such as excess steam venting or exchanger fouling and supports corrective actions that reduce fuel use and maintenance costs. This data-driven approach enhances transparency, promotes best practices across sites, and directly contributes to energy efficiency and greenhouse gas reduction goals.

Process Modeling in Municipal and Industrial Wastewater Treatment - Real-World Experiences

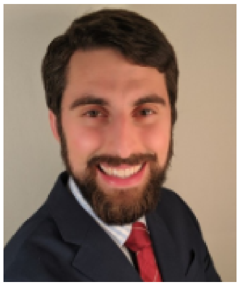

Andrew R. Shaw, Ph.D., P.E., ENV SP, BCEE
(Global Practice & Technology Leader, Black & Veatch)


Prachi Salekar, P.E.
(Process Engineer, Black & Veatch)

Black & Veatch engineers highlighted how process modeling improves the energy efficiency of municipal and industrial wastewater treatment by optimizing equipment sizing and operation. Using simulation tools like BioWin and GPS-X, models accurately predicted aeration, pumping, and nutrient removal needs, reducing overdesign and energy waste. The approach allows facilities to test process changes virtually, achieving cost-effective upgrades, and better resource utilization in real-world operations.

Addressing PFAS in Water Supplies: Regulatory Landscape, Treatment Technologies, and Industry Response


Ramanathan Ganesan
(Graduate Engineer II, Civitas Engineering Group Inc.


Corey Smith
(Project Manager, Civitas Engineering Group Inc.)


Sunil Kommineni
(President, Civitas Engineering Group Inc.)

Civitas Engineering Group presented strategies for managing PFAS contamination in water systems through energy-efficient treatment technologies like granular activated carbon, ion exchange, and reverse osmosis. The talk emphasized how optimizing system design parameters, such as empty bed contact time and hydraulic loading rate, can improve contaminant removal while minimizing energy and operational costs. By pairing innovative water treatment technologies with federal and state funding programs, utilities around the country and the world can advance both public health protection and sustainable energy use in water treatment operations.

Commentary

Laboratory Promise and the Industrial Reality: A Review of a Breakthrough Energy Efficient Catalyst

By Carla Romero

Introduction

Carbon monoxide (CO) is a primary component of syngas, which is a well-known feedstock used for decades to create a variety of chemical products. An advantage of the conversion of CO_2 to CO is that the industry already knows how to handle high-purity CO. A recent Nature study titled "Encapsulated Co-Ni Alloy Boosts High Temperature CO_2 Electroreduction" by Wenchao et al.[1] claims a significant advance by proposing a high temperature electrochemical route for CO_2 to CO conversion. This advancement affirms to achieve around 90% energy efficiency, 100% CO selectivity, and stable operation over 2,000 hours. In this article, we will analyze these claims through a thermodynamic and engineering lens which will include a viewpoint from one of our UH professors, Dr Omar Abdelrahman.

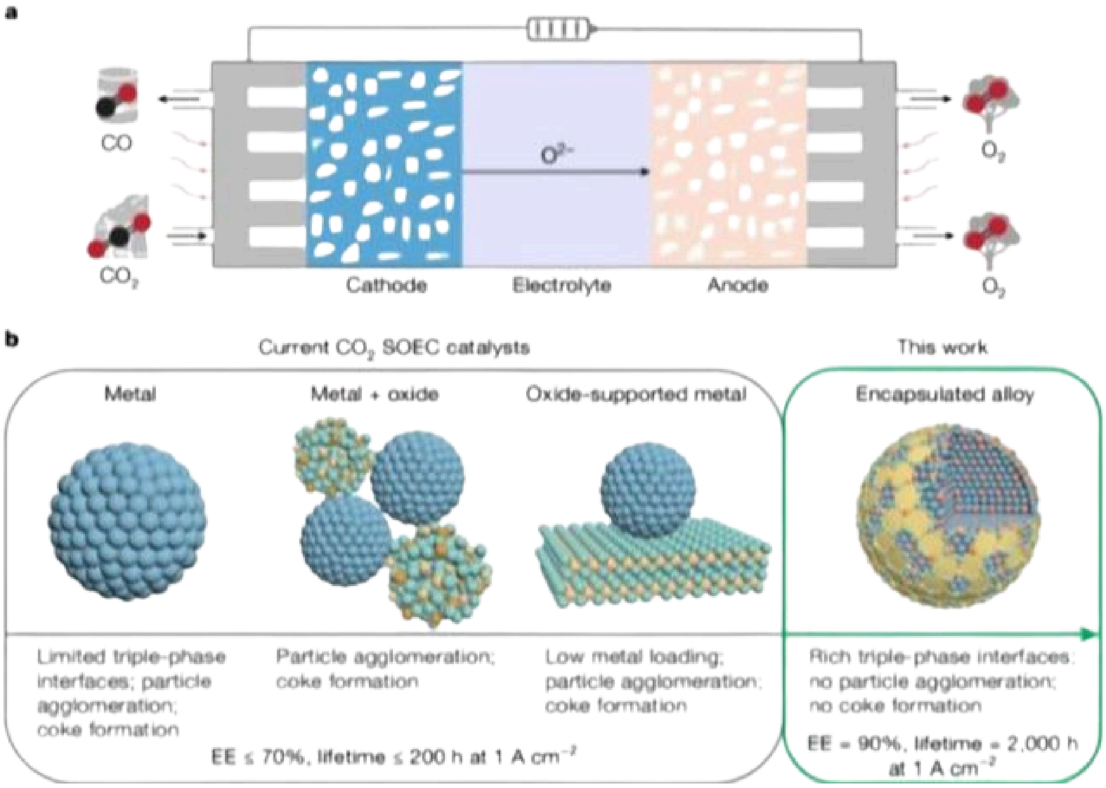


Figure 1. a, Solid oxide electrolysis cells. b, Overview of cathodecatalysts developed for CO2 SOEC. From Nature article.

Electrochemical route vs. the thermal route:

The electrochemical route for converting CO_2 to CO is a promising and efficient technology; it is defined by the following reaction:

$$CO_2 \rightleftharpoons CO + \frac{1}{2}O_2 \qquad \textit{Reaction 1}$$

This method uses electrical energy to directly drive the dissociation of CO_2. In contrast, the established industrial method is the Reverse Water-Gas Shift (RWGS) reaction that uses thermal energy and a catalyst (often based on copper, iron, or noble metals) to convert CO_2 and hydrogen (H_2) into CO and water:

$$CO_2 + H_2 \rightleftharpoons CO + H_2O \qquad \textit{Reaction 2}$$

This reaction requires a substantial input of heat, typically operating at high temperatures (500–900°C) to achieve favorable equilibrium conversion. This is an established technology, built upon decades of industrial experience in catalytic reactor design and operation. A key distinction between these two pathways is that the RWGS reaction often suffers from competing side reactions such as methanation or further hydrogenation because it operates in the presence of H_2 and H_2O. The electrochemical process, however, provides a controlled environment. By directly transferring electrons to CO_2, it minimizes unwanted side reactions and achieves higher selectivity toward CO, making it a more efficient pathway for syngas production. To analyze these claims, it is necessary to consider three fundamental points of catalytic performance: activity, selectivity, and lifetime.

Activity

The article under discussion reports 90%energy efficiency, which is theoretically possible, but the percentage is unlikely to be that high under realistic operating conditions. The efficiency (EE) of an electro chemical process is defined as where n is the number of electrons, F is Faraday's constant, together ($\Delta G/nF$) is the theoretical minimum of energy required, and *Vapplied* is the actual voltage used.

$$EE = \frac{\Delta G/nF}{V_{applied}}$$

The reported efficiency can potentially be neglecting the overpotentials associated with charge transfer kinetics, ohmic resistance in the electrolyte, and energy losses in heating and gas management. As discussed with Dr. Abdelrahman, efficiency drops when greater voltage than the thermodynamic minimum has to be applied: "If you apply two volts for a one volt process, then you're already down to 50% efficiency." It is important to note that real cells rarely operate close to the thermodynamic minimum voltage. Achieving practical current densities requires higher applied potentials, which reduce efficiency substantially. When all resistive and thermal losses are accounted for, the real system level efficiency for such a process is closer to 60 to 70%, which not overwhelmingly superior to the thermal RWGS reaction.

Selectivity

As mentioned previously, we can compare the electron transfer to "flipping a coin." Each electron may follow the intended pathway or diverge toward alternate products depending on local field effects and microkinetic competition. So the claim of 100% selectivity to CO made in the Nature paper is scientifically improbable and shows an oversimplified view of electrochemical kinetics. These results are likely short-term measurements under idealized laboratory conditions with controlled gas compositions, not long-duration industrial performance. Despite this, achieving near-perfect selectivity in a controlled experiment is a significant research achievement that is in the right track for future development. This is a significantly better approach. The electrochemical conversion of CO_2 to CO approach requires only 2 electrons, whereas creating products from CO_2, like ethanol, require around 12 electrons.

Each additional electron increases the energy cost and reduces the process's energy efficiency. Dr. Abdelrahman uses an analogy of flipping a coin to explain this: the more times you need to flip a coin, the more electrons you need to transfer, which means the higher the chance it won't go your way. A process with fewer electron transfers has a higher probability (selectivity) of producing the desired product as electrons can be diverted to unwanted side reactions.

Lifetime

Lastly, catalyst longevity is an important factor for industry deployment. The Nature study claims that the catalyst has improved stability due to its carbon-shell encapsulation of the Co-Ni alloy. This protective structure is said to mitigate sintering and oxidation, maintaining performance over extended electrolysis runs by which they claim 2000 hours of stability in a laboratory setting. These are good results for normal laboratory settings, which range from 2000–3000 hours; however, the stability is yet to be proven. Industrial reactors operate continuously beyond 2000 hours, and even minor degradation in conductivity or surface composition can rapidly decrease efficiency. While having a longer-lived catalyst is beneficial, a catalyst that retains efficiency is more important. For example, catalyst A and B can have the same lifetime, but Catalyst A can have at least a 60% efficiency for longer. Once the appropriate catalyst is chosen, the pathway and design for a chemical reaction is decided. The long-term stability of this catalyst is still to be proven.

A proposed hybrid approach

A good strategy we could use is a balance of two technologies: the electrochemical and the thermal chemistry. In this approach, electro chemistry functions as the activation step, converting CO_2 to CO through a controlled two-electron reduction, which is the aim. This is more energy efficient when isolated to this first activation step as it avoids the increase in electron demand seen in multi-carbon product formation instead of using the 12 electrons for ethanol. Downstream from this step, using thermal catalytic reactors, which are well established in the petrochemical industry, can then convert the CO and H_2 into a wide range of valuable products using other proven processes like Fischer–Tropsch synthesis and methanol synthesis. This division of function allows the electrochemical reactor to be optimized for current density, electrode stability, and heat management, while the thermal section operates under the continuous flow, high-throughput conditions that are typical in industrial plants. Furthermore, the exothermic heat released during downstream hydrocarbon synthesis can be recuperated via heat exchangers to sustain the endothermic electrochemical stage, forming a tightly coupled, energy-efficient process loop. Such heat integration aligns with the pinch analysis method, which ensures minimal entropy generation and efficient utilization of waste heat.

Conclusion

By hybridizing these domains, engineers can design an efficient approach with existing thermal infrastructure without full industrial replacement. In contrast, the fully electrochemical system proposed by Wenchao et al. would require constant high-temperature maintenance and high electrical input without comparable opportunities for thermal recovery.

1. Wenchao Ma et al., Encapsulated Co–Ni alloy boosts high-temperature CO2 electroreduction, Nature (2025). DOI: 10.1038/s41586-025-08978-0

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UH Energy is an umbrella for efforts across the University of Houston system to position the university as a strategic partner to the energy industry by producing trained workforce, strategic and technical leadership, research and development for needed innovations and new technologies. That's why UH is The Energy University®.