UH Energy
UNIVERSITY OF **HOUSTON**

TIEEP

TEXAS INDUSTRIAL ENERGY EFFICIENCY PROGRAM

Highlights from the Texas Industrial Energy Efficiency Program
Newsletter Volume 7, Number 6, February 2026

Greetings from the Texas Industrial Energy Efficiency Program!

Upcoming Events

CELC Webinar - Weatherization & Home Energy Financing: Practical Solutions for Texas Families

Thursday, February 19, 2026 | 12:00 pm - 1:00 pm

SPEER/CAPCOG Workshop – Master Your Energy Data: Save Money & Support Clean Air

Wednesday, February 25, 2026 | 9:00 am - 11:30 am
6800 Burleson Rd, Bldg. 310, Suite 165 (Pecan Room), Austin, TX, 78744

Webinar: Data Center Growth and Energy Efficiency – Meeting the Needs of Texas and Oklahoma

Wednesday, February 25, 2026 | 11:00 am - 12:00 pm
SPEER Website

Energy in Action Seminar - Artificial Intelligence in Energy Processes

Friday, February 27, 2026 | 4:00pm - 6:00pm
University of Houston Sugar Land

TRACS 2026 Summit/TEA-UP Conference

March 1 - 3, 2026
SPEER Website

Industrial Energy Efficiency Podcast

New episodes and archive here: Texas Industrial Energy Efficiency Program (TIEEP) Podcast Archive | University of Houston

Pinch Workshop and TIEEP Spring Water Forum

March 5 - 6, 2026
University of Houston Technology Bridge

Join us for a two-day workshop focused on pinch analysis and the TIEEP Spring Water Forum. Led by Alan Rossiter, President of Rossiter & Associates and former Executive Director of UH Energy, this workshop will introduce the core principles of pinch analysis and demonstrate how it can be applied to heat integration, process design, debottlenecking, waste minimization, and more. Through a blend of lectures, discussions, software demonstrations, and practical exercises, participants will gain tools they can immediately start using. They will work through real-life case studies, engage in problem-solving exercises, and receive a copy of mini-PinchExcel, a pinch targeting spreadsheet.

Workshop Details
Title: Introduction to Pinch Analysis
Dates & Times: March 5, 8:00 am – 3:30 pm; March 6, 8:00 am – 2:00 pm
Location: University of Houston Technology Bridge
Cost: For price and scholarships available check here.
Presenter: Alan Rossiter, President, Rossiter & Associates
Who Should Attend: Energy managers and engineers involved in plant operation, troubleshooting, and process design across industries such as oil refining, chemicals and petrochemicals, pulp and paper, food and beverages, and other process sectors.
For more information visit the UH Energy Events page.
Register here.

Water Forum Details

This year's TIEEP Water Forum will explore water scarcity in Texas and the impact of data center growth.
Date & Time: March 5, 4:00 pm – 6:00 pm
Location: University of Houston Technology Bridge
Cost: Attendance, both online and in-person, is FREE.
For more information visit the UH Energy Events page.
Register here.

Confirmed Speakers and Topics

Dr. Handi Rifai
"Water, Water Everywhere for Lots of Drops to Drink: The Rime of the Future Engineer"
Luis Suarez
"AI-Powered Water Treatment: Engineering Sustainable and Circular Solutions for the Next Generation"
Shiladitya (Shil) Basu
"Beneficial Reuse of Produced Water: From a Headache to a Lifeline for Data Center Development in West Texas"

STS-AIChE Dinner Meeting

The TIEEP Water Forum will be followed by STS-AIChE's monthly dinner meeting program at the same venue. The Keynote Address after dinner by Dr. Carlos Gamarra "Thirsty Data and the Lone Star State: The Impact of Data Center Growth on Texas' Water Supply."

Last Month's Events

Energy Transition Institute
UH ENERGY

Webinar Series

MULTISCALE EXPLORATION OF CRITICAL MINERALS: INTEGRATED HYPERSPECTRAL REMOTE SENSING AND GEOCHEMISTRY

JANUARY, 27 | 12-1 PM
HELD VIRTUALLY

Shuhab Khan
Professor of Geology
Department of Earth and Atmospheric Science

Energy Transition Institute Webinar Series

Dr. Shuhab Khan, Graduate Advisor and Professor of Geology (Tectonics and Geological Remote Sensing) in the Department of Earth and Atmospheric Science at the University of Houston, delivered a presentation on the growing importance of critical minerals, particularly rare earth elements (REEs), in high-tech applications such as magnets, batteries, catalysts, and phosphors. He discussed how the classification of critical minerals evolves with economic demand and supply chain considerations, and presented global maps of their distribution. The talk highlighted recent advances in imaging spectroscopy as an innovative tool for mapping mineral resources. Dr. Khan explained how hyperspectral imaging identifies minerals based on unique spectral signatures and supports multiscale exploration efforts worldwide. This webinar was recorded and can be found at this link or on UH Energy YouTube channel titled, "ETI Webinar Series: Multiscale Exploration of Critical Minerals".

HARC: Houston Advanced Research Center Visit - January 27, 2026

The visit to HARC (Houston Advanced Research Center), a nonprofit organization leading multiple impactful energy programs across the region, offered interesting insights. Carlos Gamarra, the director for the south-central region, detailed several key initiatives for which HARC has partnered with UH Energy. These included the Weatherization Assistance Program, which helps disadvantaged families prepare their homes to qualify for federal weatherization funding, and the On-Site Energy Technical Assistance Partnership, which HARC has led across five states since 2015. In collaboration with UH Energy, HARC also spearheads a program that serves as the nationwide mission integrator for the Industrial Training and Assessment Center program (ITAC), which is a DOE initiative that provides free energy audits to small and medium manufacturers. What stood out most was that along with being a hub of innovation, HARC is also a native environment and bee friendly space, featuring native plants and natural stormwater management systems throughout the grounds. Their commitment to sustainability is evident in the design of their own building, which has maintained an EPA ENERGY STAR rating of 99 out of 100 for seven consecutive years. This sustained investment in energy efficiency is remarkable and is proof that HARC practices what it advocates.

Technical Article

Hydrogen Production Energy Efficiency from Electrolysis

By Carla Romero & Hisham Habli

Introduction

In last month's newsletter (vol. 7, no. 5) we examined hydrogen production from fossil fuel feedstocks through Steam Methane Reforming and Coal Gasification in the article "Hydrogen Production Energy Efficiency from Fossil Fuels." The present article shifts the focus from fossil fuels to electrolysis. This process produces hydrogen by splitting water using electricity rather than reforming hydrocarbons.
For energy efficiency, these processes can be assessed based on first law efficiency: the energy input (LHV of feed and energy requirement) and energy output (heating values of products).

$$\eta_x = \frac{Useful\ energy\ output}{Total\ energy\ input} = \frac{LHV\ of\ hydrogen\ produced}{\sum Energy\ inputs}$$

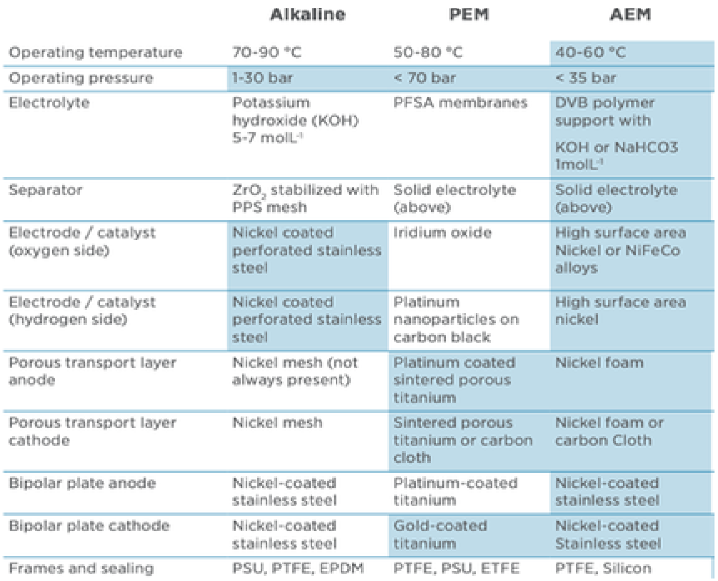
Additionally, capital expenditure (CAPEX) metrics of dollar per kilogram per day provided insight into the economic viability and commercial competitiveness of each technology.

Electrolysis

Splitting water into hydrogen and water is no easy feat. It requires a lot of energy and unique electrolysis cells.

$$H_2O \rightarrow H_2 + \frac{1}{2}O_2 \quad \Delta H = 286 kJ/mol$$

There are four types of water electrolysis: Alkaline, Proton Exchange Membrane, Anion Exchange Membrane, and Solid Oxide. In this article, I have not discussed Solid Oxide Electrolysis due to its high temperature requirement, high cost, and complexity, resulting in low use in industry.



	Alkaline	PEM	AEM
Operating temperature	70-90 °C	50-80 °C	40-60 °C
Operating pressure	1-30 bar	< 70 bar	< 35 bar
Electrolyte	Potassium hydroxide (KOH) 5-7 molL^{-1}	PFSA membranes	DVB polymer support with KOH or NaHCO3 1molL^{-1}
Separator	ZrO_2 stabilized with PPS mesh	Solid electrolyte (above)	Solid electrolyte (above)
Electrode / catalyst (oxygen side)	Nickel coated perforated stainless steel	Iridium oxide	High surface area Nickel or NiFeCo alloys
Electrode / catalyst (hydrogen side)	Nickel coated perforated stainless steel	Platinum nanoparticles on carbon black	High surface area nickel
Porous transport layer anode	Nickel mesh (not always present)	Platinum coated sintered porous titanium	Nickel foam
Porous transport layer cathode	Nickel mesh	Sintered porous titanium or carbon cloth	Nickel foam or carbon Cloth
Bipolar plate anode	Nickel-coated stainless steel	Platinum-coated titanium	Nickel-coated stainless steel
Bipolar plate cathode	Nickel-coated stainless steel	Gold-coated titanium	Nickel-coated Stainless steel
Frames and sealing	PSU, PTFE, EPDM	PTFE, PSU, ETFE	PTFE, Silicon

Alkaline Electrolysis (AE)

Alkaline electrolysis is the most mature variant of the technologies discussed in this paper. It uses a liquid potassium hydroxide (KOH) electrolyte, typically 25–30 wt%, and a porous diaphragm to separate electrodes [1]. It operates at 70–90°C with nickel-based catalysts [1]. The technology's primary limitations include restricted current density (0.2–0.4 A/cm²), slow dynamic response due to the liquid electrolyte's inertia, and challenges with differential pressure operation [2].

Alkaline electrolysis also has the lowest CAPEX of the technologies discussed.. The range for large-scale systems (1–10MW) is $900–1,332 kg per day. Low-cost nickel-based catalysts and the mineral's mature supply chain keep initial investment down. On the other hand, AE OPEX is high because of slow response and high minimum load of the process. Additional recurring costs relate to stack replacements every 60,000–90,000 hours and liquid KOH electrolyte maintenance.

Proton Exchange Membrane Electrolysis (PEM)

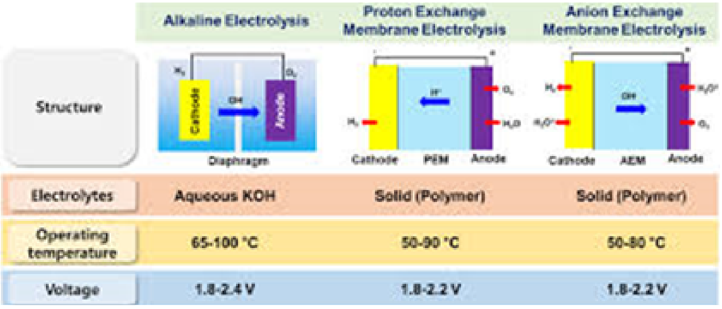
PEM electrolysis uses a solid polymer membrane, typically Nafion, that conducts protons while serving as both electrolyte and gas separator [1]. It operates at 50–80°C with deionized water feed. PEM achieves higher current densities (1–3 A/cm²) and better dynamic response, enabling rapid load-following for intermittent renewable sources [2], [3]. This technology produces high-purity hydrogen at elevated pressures (up to 70 bar) [3]. The downside is that the acidic membrane environment needs platinum-group metal catalysts (iridium at the anode, platinum at the cathode), and this significantly increases capital costs [1], [3].

PEM has a higher CAPEX than AE, at a range of $860–1,440 kg per day [4]. As previously stated, this cost is mainly driven by the use of expensive materials like the scarce iridium and platinum catalyst and the titanium bipolar plates. However, its OPEX counterbalances this, as it is the lowest among the technologies discussed. This is due to its rapid response, wide load range, longer target stack life (>60,000 hours), and the absence of a liquid electrolyte system.

Anion Exchange Membrane Electrolysis (AEM)

Lastly, AEM electrolysis uses a hybrid approach: it utilizes a solid polymer membrane that conducts hydroxide ions rather than protons [5]. This alkaline operating environment enables the use of non-precious metal catalysts (nickel, cobalt, iron-based) while retaining the compact cell design and dynamic responsiveness of PEM systems [3], [5]. Operating at 40–60°C with dilute KOH or pure water feed, AEM targets the cost advantages of alkaline technology with PEM-like performance characteristics [5]. Some of the challenges of this technology include membrane durability, which is typically <5,000 hours, lower ionic conductivity than Nafion, and carbonate formation from atmospheric CO_2 exposure [5].

The commercial viability of the newer AEM electrolyzer is still being tested. Its CAPEX is targeted to be low and projected to be in the $650–1,080 range [4]. This is again because it avoids precious metals instead using nickel, cobalt, or iron catalysts and lower-cost membranes. The OPEX is also projected to be low as it combines the rapid response of PEM with the added advantage of using low-purity water. However, its key challenge is that long-term durability and performance data at full commercial scale have not yet been fully established.



	Alkaline Electrolysis	Proton Exchange Membrane Electrolysis	Anion Exchange Membrane Electrolysis
Structure			
Electrolytes	Aqueous KOH	Solid (Polymer)	Solid (Polymer)
Operating temperature	65-100 °C	50-90 °C	50-80 °C
Voltage	1.8-2.4 V	1.8-2.2 V	1.8-2.2 V

Figure 1
https://www.researchgate.net/publication/362003482_Anion_exchange_membrane_water_electrolysis_for_sustainable_large-scale_hydrogen_production

The energy efficiency of water electrolysis is controlled by the operating cell voltage, regardless of the technology type. Cell voltage determines the electrical energy input per mole of hydrogen.

For simplicity, an average operating voltage of 2.1 V is used in this analysis, corresponding to an input energy of 405 kJ/mol and an efficiency of 60%:

$$\begin{aligned}\text{Typical Energy Input} &= n * F * V \\ &= 2 \cdot 96485 \frac{C}{mol} \cdot 2.1 V \\ &= 405 \frac{kJ}{mol}\end{aligned}$$

$$\begin{aligned}\eta_{Electrolysis} &= \frac{LHV_{H_2}}{\text{Typical Energy Input}} \\ &= \frac{242 \frac{kJ}{mol}}{405 \frac{kJ}{mol}} = 60\%\end{aligned}$$

Commercial electrolyzers all operate within a similar voltage range of 1.8–2.4 V under typical conditions, resulting in an efficiency range of 52–70%.

Conclusion

Alkaline electrolysis has the lowest capital cost and is best suited for steady, large-scale operation. PEM electrolysis costs more but handles variable power inputs better, which matters when using renewable resources like solar or wind. AEM electrolysis could offer the benefits of both, but hasn't yet proven itself at commercial scale. Surprisingly, all three technologies have approximately the same efficiency range of 52–70%, since the underlying electrochemistry imposes similar voltage requirements across all designs.

References:

[1] E. Taibi, H. Blanco, and R. Miranda, “Green Hydrogen Cost Reduction Scaling Up Electrolysers to Meet The 1.5°C Climate Goal H2O2,” 2020. [Online]. Available: www.irena.org/publications.

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[3] M. Carmo, D. L. Fritz, J. Mergel, and D. Stolten, “A comprehensive review on PEM water electrolysis,” Apr. 22, 2013. doi: 10.1016/j.ijhydene.2013.01.151.

[4] O. Toussi, “Innovations Hydrogen Production Cost by AEM Water Electrolysis,” Feb. 2021. [Online]. Available: www.ionomr.com.

[5] H. A. Miller et al., “Green hydrogen from anion exchange membrane water electrolysis: A review of recent developments in critical materials and operating conditions,” May 01, 2020, Royal Society of Chemistry. doi: 10.1039/c9se01240k.

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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
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